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**ABSTRACT**

A project was conducted at Washburn University to develop full curriculum materials for the first-year courses in an electronic maintenance technology program. The courses were articulated with a local high school. The curriculum materials were developed, pilot tested, and refined. The bulk of the report consists of the curriculum materials for these four courses: The Maintenance of Electronic Systems, Solid State Electronics, Digital Electronic Circuit Fundamentals I, and Basic Electronics. Included in the curriculum materials are course syllabuses, information sheets, assignment sheets, quizzes, and unit examinations. Materials are illustrated with line drawings. (KC)

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FINAL REPORT

ED260296

# ELECTRONIC TECHNOLOGY CURRICULUM DEVELOPMENT AND PROGRAM ARTICULATION

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Washburn University
Topeka, Kansas

Kansas State Department of Education
Division of Community Colleges and Vocational Education
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# EXECUTIVE SUMMARY

The purpose of this project was to develop full curriculum materials for the first year courses in the electronic maintenance technology program. Included in the curriculum materials are course syllabi, information sheets, assignment sheets and unit examinations. Courses which curriculum materials were developed include ET 101, PS 170, ET 110, and ET 115. Additional objectives of the project included refinement of an articulation agreement with the KAW Area Vocational-Technical school and development of a handbook on the articulation process.

Washburn developed and pilot tested curriculum materials in four electronic maintenance technology courses. Two students successfully challenged ET 110 and PS 170 courses. One of the students was a graduate of the KAW Area school. Curriculum materials developed were reviewed by an outside evaluator and suggested changes were incorporated in the final draft.

A Guide to Articulation of Programs was developed and a final dissemination workshop will be presented at the annual Vocational Education Conference in August in Manhattan, and the Kansas Association of Community Colleges meeting in October in Wichita.

## Introduction

The Kansas State Department of Education, Division of Community Colleges and Vocational Education Five Year Plan called for a need to develop high technology programs. The plan also addressed the need to foster articulation between institutions providing vocational education programs in similar career fields. This project addresses these two goals.

## Personnel and Participants

The primary personnel involved in this project were William S. Dunlap, Reid A. Holland and Jim Jaworski. Other participants include members of the program articulation committee and the program advisory board (Appendix A) consultants to Washburn on this project were Dr. O. A. Brown and Dr. Charles Dollar.

## Procedures and Methodology

An Eric search was conducted to identify literature on vocational program articulation agreements. Members of the program articulation committee met on several occasions throughout the year to develop the articulation agreement between Washburn University and the KAW Area Vocational-Technical School.

Because of the limited technical content of the career oriented electronic program at Topeka West High School, and by mutual agreement, Washburn University and Topeka West High School decided not to pursue a written agreement between the two institutions.

Curriculum materials were developed for first year electronic courses at Washburn in the following areas:

- ET 101 The Maintenance of Electronic Systems
- ET 110 Solid State Electronics
- ET 115 Digital Electronic Circuit Fundamentals I
- PS 170 Basic Electronics

Included in the curriculum materials are course syllabus, information sheets, assignment sheets and unit examinations. These curriculm materials were used by first year students during the 1984-85 academic year.

Student evaluations were conducted in each course at the close of the semester. Dr. A. O. Brown also reviewed draft stages of the curriculum materials.

Two student opted to take challenge examinations in ET 110 and PS 170. These students were successful. One of these students was a former graduate of the KAW Area Vocation-Technical School.

A handbook was developed to assist other institutions in reaching articulation agreements with one another. Copies of the handbook will be disseminated at two state conferences for community college and vocational-technical school personnel.

## Achievement of Objectives

Objective 1: Pilot test first year.

Courses developed through FY 85 project.

Full curriculum materials were developed for first year courses of ET 101, PS 170, ET 110 and ET 115. (Appendix B) These materials were pilot tested during the 1984-85 academic school year.

Objective 2: Develop competency test for common units of instruction between programs.

The common units of instruction were identified as the courses of ET 110, PS 170, and ET 115 between Washburn and KAW Area Vocational-Technical School. The competency test for these courses were developed from a sampling of questions from each instructional unit for each of these courses.

Objective 3: Evaluate pilot courses and corresponding competency test.

Courses were evaluated through student evaluations at the end of the course (Appendix C) and by Dr. A. O. Brown (Appendix D). Dr. Brown and Dr. Charles Dollar also provided an overall external evaluation of the project.

Objective 4: Monitor students selecting to challenge the articulation option.

Two students successfully challenged ET 110 and two additional students successfully challenged PS 170. One of these students was a graduate of the KAW Area Vocation-Technical School.

Objective 5: Develop model articulation agreement.

A model articulation agreement was developed (Appendix E) and was also included in the Guide to Articulation of Programs.

Objective 6: Develop an articulation guideline handbook.

An articulation handbook was developed (Appendix F) and included an articulation model, barrier to the process, need for articulation, aids to the process, timetable for articulation and benefits of the process.

Objective 7: Coordinate on-going meetings with the three articulation projects (Tonganoxie USD 464, Dodge City Community College and Washburn University.

This objective was dropped at the beginning of the project at the request of the Coordinator of the Research Coordinating Unit of the Division of Community Colleges and Vocational Education, Kansas State Department of Education.

Objective 8: Deliver a statewide dissemination of model courses and articulation agreements.

This objective will be accomplished through dissemination workshops conducted at the Kansas Vocational Education Conference in Manhattan (August, 1985) and the Kansas Association of Community Colleges meeting in Wichita (October, 1985).

## Results and Outcomes of Project

Results and outcomes of this project are as follows:

1. Identification of literature on vocational education articulation.
2. Development of a model articulation agreement.

3. Provide for more effective use of resources by cooperation between institutions.
4. Provides advanced standing for students for previous educational experiences.
5. Opened communication channels for developing future agreements in other programs between the participating institutions.
6. Provide competency based educational instruction.
7. Articulation handbook will assist other local education agencies in articulating programs.

Products Resulting from Project

The following products were a result of this project:

1. Competency based curriculum guides were developed for first year technical courses of Washburn program.
2. An articulation model was developed.
3. An articulation handbook was developed.

Conclusions and Recommendations

Based on the findings of this project, the following conclusions and recommendations were made.

1. Second year course curriculum packages should be developed.
2. Further monitoring of students from KAW Area Vocational-Technical School entering Washburn University as electronic maintenance technology students.
3. This project should be extended for a third year to complete recommendation #1 and 2.

# Appendix A

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# Appendix B

## Curriculum Guides

## for

ET 101 The Maintenance of Electronic Systems

PS 170 Basic Electronics

ET 110 Solid State Electronics

ET 115 Digital Electronic Circuit Fundamentals I

# ELECTRONIC MAINTENANCE TECHNOLOGY PROGRAM

## MAINTENANCE OF ELECTRONIC SYSTEMS

## ET 101

Learning for a Lifetime
WASHBURN UNIVERSITY
School of Applied and
Continuing Education

# ELECTRICAL MAINTENANCE TECHNOLOGY PROGRAM
# ET 101
# MAINTENANCE OF ELECTRONIC SYSTEMS

SCHOOL OF APPLIED AND CONTINUING EDUCATION
WASHBURN UNIVERSITY

# FORWARD

In 1983, the Vocational Administration Section of the Kansas State Department of Education provided a grant to the School of Applied and Continuing Education at Washburn University to develop a two year associate degree program in the emerging high technology field of electronics. These curriculum materials are one of the products of that project. This curriculum package includes the course syllabi, study guide, information sheets, laboratory sheets, assignments sheets and unit examinations.

The materials in this package have been prepared in a sequence that best matched our situation. The individual instructor may add, delete or rearrange to his/her own needs.

Assistant Professor, Jim Jaworski is the author of these curriculum materials and is to be congratulated for his work. Our special thanks also go to the support staff in the School for their assistance with graphics, typing and editing of these materials.

William S. Dunlap

and

Reid A. Holland
Project Directors

Funding for this project was provided through the Research Coordinating Unit, Division of Community Colleges and Vocational Education, Kansas State Department of Education under Public Law 94-482, subpart 3, section 132.

State Reference No. 85-132-03

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# ET 101

# Maintenance of Electronic Systems
2 Semester Hours

School of Applied and Continuing Education
Washburn University

Fall 1984

J. Jaworski, Professor

## INTRODUCTION

The Maintenance of Electronic Systems has been developed as an introductory course in the Electronics Maintenance Technology. A prerequisite knowledge of electricity/electronics is not required. The course has been specifically designed to provide an overview of the Electronics Maintenance Program. In addition, practical, real-life applications of electronics will be observed by industrial visitations and guest lecturers.

## COURSE ORGANIZATION

The class will meet, each Monday evening from 6:45-9:30 p.m. Lecture and other activities have been designed to take place during these sessions. One fifteen minute break will be permitted at the midpoint of the session at the discretion of the instructor.
NOTE: Due to Labor Day recess, there will be no class meeting September 3, 1984.

## COURSE OBJECTIVES

Upon the completion of the course the student should be able to:

1. Identify electronic component symbols
2. Perform simple 4 function mathematical calculations
3. Convert binary to decimal numbering systems from one to the other
4. Correctly identify electronic components
5. Understand the basic uses of the VOM, DVM, Oscolloscope, etc
6. Identify the various symbols associated with electronic measurements (mA, mV, MΩ, etc.)
7. Convert electrical units from one value to another (1000 mA = 1 amp)
8. Understand the basic concepts of electrical safety
9. Be cognizant of the variety of options available within Electronic Maintenance (tours, guest lecturers)
10. Understand the significance of corrective preventive and predictive maintenance

11. Analyze the need of a microprocessor in a microprocessing application (microprocessor paper)

12. Develop a personal definition of Electronic Maintenance. (Thought paper)

13. Identify commody used electronic formulas

14. Read resistor color code values

## EVALUATION

Tests (50% of the total grade)

All major evaluations will contribute an equal percentage regardless of the number of evaluations during the course of the term. The number of evaluations may range from two through four with the following table listing the applicable percentages:

Two Evaluations....................25.0% each
Three Evaluations..................16.6% each
Four Evaluations...................12.5% each

The Final Examination will be given as listed in the fall schedule of classes. The Final Examination date and time is: Monday, December 17, 1984, beginning at 6:45 p.m. and ending at 9:30 p.m.

## EVALUATION REVIEW PROCEDURES

The following procedures will be utilized for the review of all major evaluations:

1. Answers will be given in class to check for mechanical grading errors. Comments regarding the agreement or disagreement to a response will not be invited at this time.

2. If a disagreement exists, follow the procedure below:

   A. On the top of the front page of the test, write the number of the question you disagree with.

   B. Locate the page on which the question you disagree with appears. On the back of this page, write your reasons why your response should be considered correct.

   C. Repeat this procedure as often as necessary.

3. Sufficient time will be provided for the individual accomplishment of step two. Those not wishing to respond are to remain silent during this period. There is to be no discussion during this period by any class members.

4. After completion of all written input, the examination will then be reviewed. All responses made during this review process will not have any bearing on any individual's grade, as only the written response will be considered.

5. During this discussion period, all writing on the examination must cease. Those continuing to respond will be considered to be cheating.

6. Individuals not participating in the test review procedures forfeit their right to alter their test score at a future date, i.e. all debate must be made in writing on the test itself.

7. Examination papers will be made available for review purposes on an individual basis. These test materials are not to leave the Instructor's office.

## GRADING SCALE

All class evaluation will be based on the grading scale listed below. The indicated percentge designates the bottom of the respective grade zone, i.e., 85% is the bottom of the B's. An individual earning an 84% would receive a grade of C, etc.

| | |
|---|---|
| A | 93% |
| B | 85% |
| C | 77% |
| D | 69% |

Individual grades will not be issued during the course of the term. It is your responsibility to record all test scores and calculate any applicable letter grades. As an example: a test has 86 possible points. Your score is 76. Divide 76 by 86 and the percentage is 88.4%. The equivalent letter grade from the chart is a grade of "B".

## QUIZZES
(15% of the total grade)

Quizzes are considered to be short announced or unannounced examination consisting of ten to twenty-five points and spaced spasmodically throughout the course. In addition, quizzes can NOT be made up. Generally, a missed quiz will result in a grade of zero being entered into the record for that particular quiz. However, each individual is allowed to miss one quiz without penalty.

## THOUGHT PAPER
(15% of the total grade)

Thought papers consist of a one to two page typed (150-225 word) paper regarding your definition of Electronic Maintenance and its modification by the guest lecture-tour input. Papers will be required one week after the guest lecture-tour has transpired.

## MICRO-PROCESSOR PAPER
(20% of the total grade)

The micro-processor paper will consist of one indepth report that is typed ranging from 6 to 8 pages in length. (1200-1600 word) This assignment will be due 10 December 84 and will basically address the use of the processor in an operation that is now being done manually.

## LATE POLICY

In general, materials to be handed in are due at the beginning of the class period. These materials are considered late if presented after the announced due date unless otherwise specified. Materials received late will not be graded.

If you anticipate being absent, these materials may be handed in early, delivered to my office (Room 124, Benton Hall), placed in my faculty mailbox, or presented by a fellow student during the regularly scheduled class period.

## WORK MISREPRESENTATION

All work produced is expected to be your own material. Plagiarism, cheating, or other forms of academic dishonesty are not tolerated. Those being observed in such circumstances will not receive credit for the course.

The instructor reserves the right to alter this syllabus as required.

ET 101
Electronic Maintenance
Pre-Test

Name________________________________

75 points 27 August 84

## SECTION #1 TRUE OR FALSE (12 points)

The following statements are either True or False. Indicate the most correct response by encircling the T or F.

T F 1. mV is the symbol for millivolts.

T F 2. One pico farad is equal to .000000000001 farad.

T F 3. A VOM will provide a correct reading when measuring four volts across a 10 M ohm resistor.

T F 4. A two watt resistor is physically larger than a ½ watt resistor.

T F 5. $18.7 \times 10^6$ is in the proper scientific notation form.

T F 6. A ½ watt resistor is capable of dissipating twice as much power as a ¼ watt resistor.

T F 7. mA is the symbol for mega amps.

T F 8. One kilo is equal to $1 \times 10^3$.

T F 9. .5 amps is equal to 500 milliampers.

T F 10. An oscilloscope can be used to measure TTL logic levels.

T F 11. It is correct procedure to express 1,600 ohms as 1.6k ohms.

T F 12. A G.F.I. circuit will turn off the power when there is a current unbalance of .005 amperes.

## SECTION #2 MULTIPLE CHOICE (6 points)

Indicate the correct or most correct response by encircling the correct letter (A, B, C, D, E).

13. In the formula $E = IXR$, the E stands for:

A. Resistance
B. Current
C. Voltage
D. Amps
E. Ohms

14. In the formula $X_L = 2\pi FL$, the L stands for

A. inductance
B. current
C. voltage
D. 3.1416
E. leakage

15. If a machine is broken it will require

A. corrective maintenance
B. preventive maintenance
C. predictive maintenance
D. load cell maintenance
E. piezoelectric maintenance

16. In the formula $R = \frac{E}{I}$, the R stands for

A. resistance
B. resonance
C. voltage
D. Reactance
E. Resolution

17. In the formula $P = I^2XR$, the P stands for

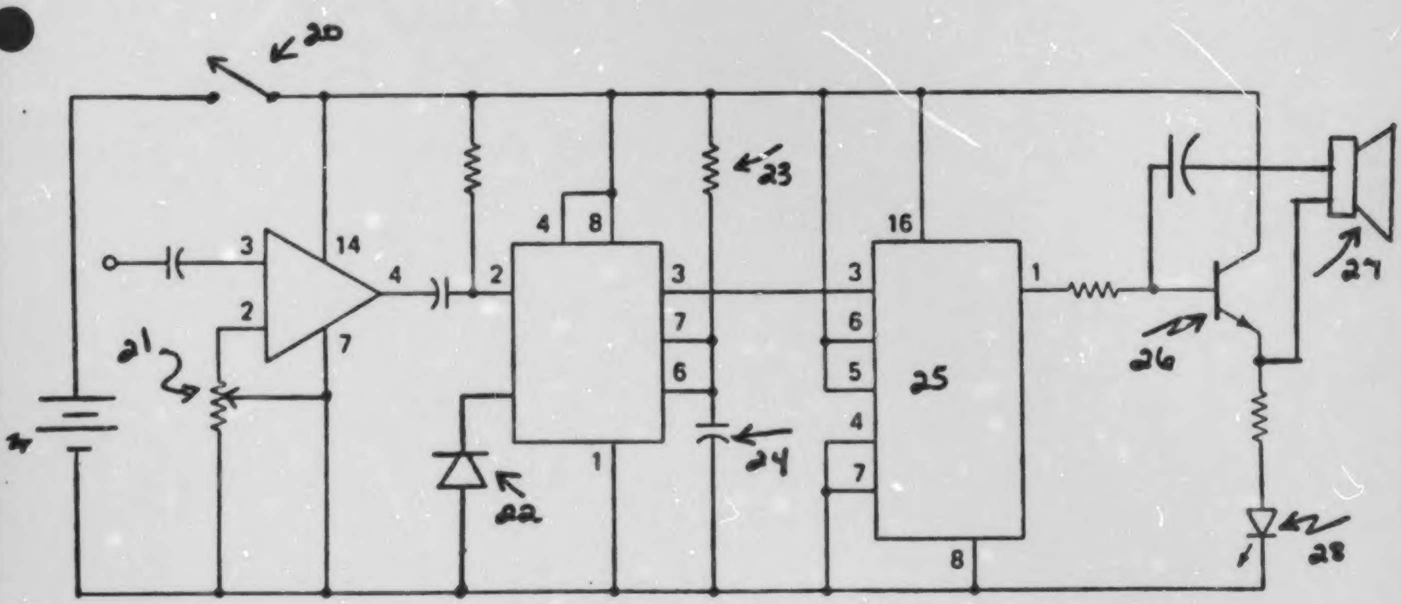
A. horse power
B. foot pounds
C. current
D. amps squared
E. power

18. A resistor is color-coded yellow, violet, orange and silver. Its value is:

A. 2.7k ohms
B. 4.7k ohms
C. 47k ohms
D. 470k ohms
E. None of the above

## SECTION #3 IDENTIFICATION (10 points)

Using the provided diagram identify the indicated parts by placing the correct name of the part in the provided blank.



19.__________________________

20.__________________________

21.__________________________

22.__________________________

23.__________________________

24.__________________________

25.__________________________

26.__________________________

27.__________________________

29.__________________________

## SECTION #4 FILL IN (30 points)

Fill in the blank with the most correct answer.

29. The sum of 10 plus 8 plus 19 is __________________________.

30. The abbreviation LSI stands for __________________________.

31. Four times twenty-three is equal to __________________________.

32. The abbreviation CPU stands for __________________________.

33. 107 minus 39 is equal to __________________________.

34. The abbreviation RAM stands for __________________________.

35. A resistor with the bands (L to R) of red, black, red, and gold has a value of __________________________.

36. Convert the decimal number of 65 to its binary form. ______________.

37. TTL stands for ______________________________.

38. The square of 8 is equal to ______________________________.

39. The binary number 10010 is equal to ______________________________.

40. The initials VOM stands for ______________________________.

41. The square root of 9 is equal to ______________________________.

Directions: Convert the following quantities to scientific notation (powers of 10).

42. 18,000 ______________________________

43. 0.321,000,000 ______________________________

44. 56.18 ______________________________

Directions: Convert the following expressions to power of tens or from power of tens to unit quantities.

45. .01764 = ______________________________

46. 2,340,000 = ______________________________

47. $4.9 \times 10^{-3}$ = ______________________________

Directions: Determine the correct response in powers of ten. (No calculator use allowed)

48. $2 \times 10^{3} + 8 \times 10^{-1}$ = ______________________________

49. $4 \times 10^{-2} \times 4 \times 10^{6}$ = ______________________________

50. $\frac{8 \times 10^{6}}{2 \times 10^{4}}$ = ______________________________

Directions: Identify the following prefixes in power of tens. (Example: Tera = $10^{12}$)

51. Mega ______________________________

52. Pico ______________________________

53. Kilo ______________________________

54. Milli ______________________________

55. Micro-micro ______________________________

Directions: Convert ohms into the appropriate form. (Example: 1200 Ω = 1.2 K Ω )

56. 4.7 Ω = ____________________

57. 330,000 Ω = ____________________

58. 15,000,000 Ω = ____________________

### SECTION #5 COMPONENT IDENTIFICATION (12 points)

Correctly identify the components by placing the name of the component in the correct blank.

59. ____________________
60. ____________________
61. ____________________
62. ____________________
63. ____________________
64. ____________________
65. ____________________
66. ____________________
67. ____________________
68. ____________________
69. ____________________
70. ____________________

### SECTION #6 DEFINITION (5 points)

In your own words define electronic maintenance.

71.
72.
73.
74.
75.

# Electronic Maintenance
## ET 101

Test #1 5 November 1984

82 points Name____________________

**Section #1 True or False (26 points)**

The following statements are either true or false. Indicate your response by circling either the T or F.

T F 1 An AC voltage is commonly available in our homes.

T F 2 A DVM or DMM can only measure relatively steady state signals.

T F 3 A two watt resistor is physically smaller than a ¼ watt resistor.

T F 4 A rectifier converts DC to AC.

T F 5 A 30mHz oscilloscope is capable of accuracy displaying a 150 mHz signal.

T F 6 A DC meter movement can be used with the appropriate circuitry to measure both DC and AC current and voltage.

T F 7 A resistor of red red orange gold has a tolerance of ± 2%.

T F 8 A pot can be connected as a rheostat to vary the amount of current in a circuit.

T F 9 Digital signals are commonly used in microcomputers for the transfering of information within the processor.

T F 10 It is impossible to measure resistance with a DMM or a DVM.

T F 11 An inductor is used to stop the flow of AC but allows DC to pass.

T F 12 A battery supplies an EMF.

T F 13 A transistor is a 3 terminal active device.

T F 14 The oscilloscope allows one to "see" what the signal actually looks like.

T F 15 A switch is used to open and close a circuit.

T F 16 An example of an analog signal would be the signal being delivered to a loudspeaker.

T F 17 A resistor impedes the flow of electrons.

T F 18 A VOM is basically used to measure current, voltage and resistance.

T F 19 A power meter is calibrated in watts and measures the power generated from an RF transmitter.

T F 20 A resistor without a fourth band has a tolerance of ± 5%.

T F 21 The best device to measure time varying signals is the oscilloscope.

T F 22 An LED is a solid state light.

T F 23 An oscilloscope is used to measure the RF power generated by a CB radio.

T F 24 A capacitor is used to block AC, but allows DC to pass.

T F 25 A diode converts AC into pulsating DC.

T F 26 A resistor of orange violet silver gold has a value of .47 ohms.

## Section #2 Short Answer Fill In (56 points)

Fill in the blanks with the requested information.

Convert the following to scientific notation (5 points).

27 17621 ______________

28 0.321,000 ______________

29 26.81 ______________

30 .0007021 ______________

31 521,212,000 ______________

Convert the following from powers of ten to unit quantities (5 points).

32 $2.6\times10^{-4}$ ______________

33 $1.02\times10^{3}$ ______________

34 $9.6\times10^{-8}$ ______________

35 $6\times10^{-1}$ ______________

36 $1.861\times10^{7}$ ______________

Indicate the power of ten associated with each of the below prefixes. (5 points)

37 pico ______________

38 kilo ______________

39 mega ______________

40 milli ______________

41 micro ______________

Convert the following into the proper electronic units (5 points).

42 .250 amp ____________

43 1850 watts ____________

44 470,000 ohms ____________

45 .000021 amps ____________

46 96 volts ____________

Identify the following resistor values. Place answer in the correct units (4 points).

47 Red orange brown silver ____________

48 Blue gray green gold ____________

49 Brown violet gold gold ____________

50 Orange white green silver ____________

51 A resistor of green blue red gold has a value of __________
52 ohms and a maximum resistance of _________ ohms and a minimum
53 resistance of _________ohms in order to be in tolerance.
(3 points)

Perform the conversions (4 points)

54 0.37M ohm ____________k ohms

55 0.167 u sec ____________seconds

56 862 mA ____________u amps

57 1.430 MHz ____________KHz

Given the following abbreviations, state what they stand for. (7 points)

58 I ____________

59 Hz ____________

60 C ____________

61 R ____________

62 uv ____________

63 Mw ____________

64 L ____________

65 The abbreviation AC stands for ______________________________.

66 The abbreviation DC stands for ______________________________.

67 The abbreviation RF stands for ______________________________.

68 The abbreviation DPST stands for ____________________________.

69 The abbreviation DVM stands for _____________________________.

70 The name of a device used to measure the RF frequency of a transmitter is ______________________________________.

71 State one use of a spectrum analyzer.

______________________________________________________________

72 Draw one cycle of an AC sine wave. (1 point)

73 List two disadvantages of the VOM. (2 points)

1

2

Draw the correct symbols for the following electronic components (8 points)

75 diode

76 capacitor

77 transistor

78 ground

79 pot

80 switch (SPST)

81 resistor

82 battery

# ET 101
# Electronic Maintenance Technology
# Final Exam

82 points Name______________________________

Section I TRUE or FALSE (21 points). The following statements are either true or false. Indicate the most correct response by circling either the T or F.

T F 1. A cursor key moves the cursor up, down, right and left.

T F 2. The program counter keeps track of the sequence of computer instructions to be executed.

T F 3. A computer can handle real time problems fast and accurately.

T F 4. A dot matrix printer is considered to be a letter quality printer.

T F 5. A computer program is a series of instructions prepared in a form that is acceptable to the computer which will achieve a certain result.

T F 6. The power lines on a processor chip supplies the chip with binary data and system timing.

T F 7. Hard disks have the capability of being inserted and removed in the same manner as floppys for programming purposes.

T F 8. The accumulator interfaces the computer with the outside world.

T F 9. A digital computer manipulates binary information and is capable of accepting, comparing, adding, subtracting, multiplying, dividing and integrating this information.

T F 10. Computers in general, use the same operating system to maintain system to system compatability.

T F 11. A QWERTY keyboard is the least desirable of all the keyboards available for computer data input.

T F 12. The main purpose of a clock in the computer system is to inform the operator of the time and day of the week.

T F 13. A high resolution monitor creates images that are crude and hard to read.

T F 14. It is difficult to locate a hand held computer that contains a full-sized keyboard.

T F 15. A modem is a device that can connect computers together via the telephone system.

T F 16. A LCD is capable of color, high-resolution and a 12 inch screen.

T F 17. The ALU performs the logical operations, decision making functions, and math operations in the computer.

T F 18. The best selling computer is the machine classified as the portable computer.

T F 19. It is difficult to change a computer from one task to another, as a hardware change must be made.

T F 20. A computer instruction is a binary word that defines a specific function that is to be performed.

T F 21. Software written for an IBM computer will run without modification on the Apple or a Vic-20.

Section #2 MULTIPLE CHOICE (13 points). Indicate the correct or most correct response by circling the statement number.

22. A computer consists of four basic parts. The function that is not one of these is:

1. output
2. graticule
3. processor
4. memory
5. input

23. A memory location is given a numbered location called a/an:

1. address
2. input
3. latch
4. parity
5. bootstrap

24. To produce letter quality print a printer uses a:

1. daisy wheel
2. thermal hammer
3. dot matrix
4. pin feed
5. friction feed

25. The type of printer that runs the fastest is the:

1. daisy wheel
2. querty
3. thermal
4. LCD
5. dot matrix

26. Business software would include programs in

1. speed reading
2. accounting
3. music composition
4. games
5. engineering

27. The part of the computer that stores the program and data is the

1. input
2. memory
3. output
4. control

28. The type of memory device that is the slowest and the least expensive is:

1. cartridge
2. floppy disk
3. punched cards
4. cassette tape
5. hard disk

29. The entertainment computer is used for:

1. managing your home
2. improving personal productivity
3. word processing
4. creating a budget
5. playing arcade-type games

30. A microcomputer is a fully operational digital computer that is based on:

1. inputs
2. printer interfaces
3. a microprocessor chip
4. instruction codes
5. device select pulses

31. One of the common interface ports on a computer is the

1. RS 232C
2. IEE-844
3. Parallel RS 322
4. Serial IEEE
5. RS 2320A

32. The type of mass memory that is the most expensive but has the most memory is:

1. cartridge
2. floppy disk
3. softsectored floppy
4. cassette tape
5. hard disk

33. The type of printer that is the least expensive is the:

1. Querty
2. thermal
3. daisy wheel
4. dot matrix
5. LCD

34. The type of computer keyboard that is the most desirable in a heavy industrial environment is:

1. membrane
2. calculator style
3. typewriter style
4. detachable
5. decoder type

Section #3 SHORT ANSWER FILL IN (20 points). Fill in the blanks with the requested information.

35. To easily use a computer for word processing the video monitor must display a certain number of columns. For this application the number of columns are __________.

36. DOS is a term associated with computer systems. It is an abbreviation for ______________________________.

37. The abbreviation CPU stands for ______________________________.

38. ALU is the abbreviation for ______________________________.

Given the following letter symbols, state their correct meaning. (10 points)

39. AC ____________________

40. ⎍ ____________________

41. I ____________________

42. uf ____________________

43. mHz ____________________

44. E ____________________

45. kHz ____________________

46. R ____________________

47. DC ____________________

48. P ____________________

Draw the correct symbols for the following electronic components (6 points)

49. ground

52. transistor

50. battery

53. capacitor

51. resistor

54. air inductor

Section IV MATCHING (28 points). Place the numbered response of your choice in the provided space.

55. ______ A/D
56. ______ ASC II
57. ______ Assembler
58. ______ Basic
59. ______ Baud
60. ______ Bidirectional
61. ______ Binary
62. ______ Bug
63. ______ Bus
64. ______ CPU
65. ______ Command
66. ______ Cursor
67. ______ Data
68. ______ Disk drive

69. ______ EPROM
70. ______ Expansion slot
71. ______ Hard Disk
72. ______ Hardware
73. ______ Joystick
74. ______ Menu
75. ______ Microcomputer
76. ______ Microprocessor
77. ______ Nonvolatile
78. ______ PROM
79. ______ RAM
80. ______ ROM
81. ______ Software
82. ______ User-friendly

1. A disk drive that can store millions of bites of data.
2. A device that can read and write information on a magnetic disk.
3. A base-sixteen number system.
4. Programs, instructions & procedures written for a computer system.
5. A memory device that will continue to store data after power is removed.
6. The ability of a device or computer to send data in two directions.
7. The smallest picture element on a computer screen.
8. An erasable programmable read-only memory.
9. The principal electronic component in the microcomputer.
10. Routinely active memory.
11. A game controller that moves an object around a video screen.
12. A specific computer code that tells what each keyboard character stands for.

13. A video display position indicator.

14. Actual computer equipment.

15. Programmable read only memory.

16. A device that converts analog data to binary data.

17. A computer socket that allows additional memory or other devices to be connected to the computer.

18. A list of choices within a computer program (sub program availability)

19. Read only memory.

20. A machine that is easy to use.

21. A device that produces printed copy.

22. A floppy disk that has become inflexible after years of use.

23. A physical conductor used as a path for internal computer data transfer.

24. Personal read only memory.

25. A base ten numbering system.

26. An instruction that tells the computer to do something.

27. Routinely on memory.

28. A base two numbering system.

29. Information fed into or out of a computer.

30. A commonly used computer language most often used for the home computer.

31. A device for drawing computer pictures.

32. Random access memory

33. The measurement of the rate at which computer data is transferred from one point to another.

34. The total computing system containing hardward and software.

35. Electrically erasable programmable read only memory.

36. A software program that converts keyboarded information into binary equivalents.

37. The brain of the computer.

38. An error in either the software or hardware.

39. Rapid access memory.

# ET 101
# ELECTRONIC MAINTENANCE
## LETTER SYMBOLS AND ABBREVIATIONS

QUIZ #1
10 points

Name______________________________

1. dc ________________

2. E ________________

3. C ________________

4. P ________________

5. kwh ________________

6. ~ ________________

7. M ________________

8. uf ________________

9. uv ________________

10. Ma ________________

### ET 101
### ELECTRONIC MAINTENANCE
### RESISTORS

QUIZ #2
10 points

Name ______________________

1. Using the resistor color code fill in the missing values.

White_____ Blue_____ Black_____ Green_____

2. Identify the following resistor values

Red Red Orange Silver _______

Brown Black Gold Gold _______

Yellow Violet Silver Gold _______

Gray Red Yellow _______

3. Define resistance

4. The fourth band on a resistor is used for what purpose?

ET 101
ELECTRONIC MAINTENANCE
UNITS

QUIZ #3
10 points

Name ____________________

Convert the following into the proper electronic units:

1,200,000 ohms ____________________

.0001 Amps ____________________

1250 watts ____________________

100 volts ____________________

1786 mA ____________________

47,000 ohms ____________________

.1 Amp ____________________

7,800,000 uV ____________________

.88 kilovolt ____________________

875 ohms ____________________

ET 101
ELECTRONIC MAINTENANCE
COMPUTERS

QUIZ #4
10 points

Name: ____________________________

1. State one advantage for purchasing a computer for computer literacy.

2. State one advantage of purchasing a computer system that has a widely used operating system.

3. DOS stands for ____________________________________________

4. Define software What is it?

5. What does IBM compatible mean?

6. Define resolution.

7. How many columns are necessary for efficient word processing? ______

8. Your computer has the ability to accept RS232C and IEEE488. What does this mean?

9. Name one computer peripheral.

10. When purchasing a computer, what is the first question that you should ask yourself?

ET 101
ELECTRONIC MAINTENANCE
ELECTRICAL UNITS AND CONVERSIONS

INFORMATION SHEET #1

## ELECTRICAL QUANTITIES

| Electrical Quantity | Letter Symbol | Basic Unit | Abbreviation for Basic Unit |
|---|---|---|---|
| charge | Q | Coulomb | |
| electromotive force | E | volt | V |
| current | I | ampere | A |
| resistance | R | ohm | Ω |
| power | P | watt | W |
| conductance | G | mho | ℧ |
| inductance | L | henry | h |
| capacitance | C | farad | F |
| frequency | f | hertz | Hz |

UNITS

The basic unit carries the descriptive name for the electrical quantity, such as ampere, ohm, and volt. Multiples are units which are larger than basic units; examples are the kilovolt (one thousand volts), the megawatt (one million watts), and the gigahertz (one billion hertz). Submultiples are units which are smaller than basic units; examples are the milliampere (one thousandth ampere), the microwatt (one millionth watt), the nanosecond (one billionth second), and the picofarad (one trillionth farad). This shows the use of prefixes to create names for multiples and submultiples.

The Table shows the relationship between the seven prefixes that are most common in electronics work.

PREFIXES COMMONLY USED IN ELECTRONICS

| Prefix | Abbrev. | Power of 10 Numerical Equivalent |
|---|---|---|
| giga | G | $10^9$ |
| mega | M | $10^6$ |
| kilo | k | $10^3$ |
| ... | ... | $10^0$ |
| milli | m | $10^{-3}$ |
| micro | μ | $10^{-6}$ |
| nano | n | $10^{-9}$ |
| pico | p | $10^{-12}$ |

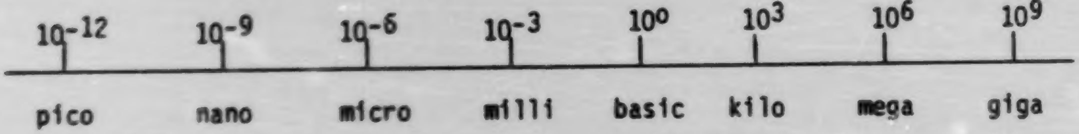
|  | ABBREVIATED FORMS |  |  |
|---|---|---|---|
| Value | Powers of 10 Form | Prefix Form | Fully abbrev. Form |
| 1,000,000,000 hertz | $10^9$ Hz | 1 gigahertz | 1 gHz |
| 1,000,000 ohms | $10^6$ Ω | 1 megohm | 1 M Ω |
| 1,000 watts | $10^3$ W | 1 kilowatt | 1 kW |
|  | BASIC UNITS (NO PREFIX) |  |  |
| 0.001 ampere | $10^{-3}$ A | 1 milliampere | 1 mA |
| 0.000,001 mho | $10^{-6}$ ℧ | 1 micromho | 1 μmho (μ ℧ ) |
| 0.000,000,001 second | $10^{-9}$ sec | 1 nanosecond | 1 nsec |
| 1 one-trillionth farad | $10^{-12}$ F | 1 picofarad | 1 pF |

ET 101
ELECTRONIC MAINTENANCE
UNIT CONVERSIONS

## INFORMATION SHEET #2

Both the study and application of electronics often require conversion from one size unit to another. One important reason for conversion is that practically all general equations are stated in terms of basic units. We often need to convert from multiples or submiltiples to basic units, so that these basic unit values may be substituted for letter symbols in the general equations. We may then find a numberical solution to the equation.

The below may help us to visualize the unit conversion process. Here we have a prefix scale showing the prefixes commonly used in electronics, and the powers of 10 associated with the prefixes.



A PREFIX SCALE THAT IS USEFUL FOR UNIT CONVERSION

The procedure for using the prefix scale is as follows:

1. When converting to larger units, enter the scale with the prefix given and move to the right. Multiply by $10^3$ at each prefix point. Write the new prefix in the converted form.
2. When converting to smaller units, enter the scale with the prefix given and move to the left. Multiply by $10^{-3}$ at each prefix point. Write the new prefix in the converted form.

EXAMPLE 1: To convert from micro-units to milli-units, enter the scale at micro and move to the right to milli; multiply your value by $10^3$.

Solution: $4\ \mu A - 4 \times 10^{-6} \times 10^{3}\ mA = 4 \times 10^{-3}\ mA$

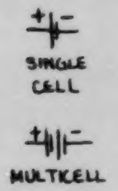
## ET 101
## BASIC ELECTRONICS
## COMMON SYMBOLS AND ABBREVIATIONS

INFORMATION SHEET #3

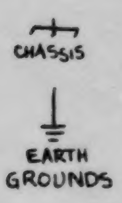
| | | | |
|---|---|---|---|
| ac | alternating current | f | frequency |
| dc | direct current | fr | resonant frequency |
| I | amperes, current | t | time |
| E | voltage | kHz | kilohertz |
| R | resistance | Ω | ohms |
| W | watts (power) | M | meg-, million |
| X | reactance | u | micro, millionth |
| L | inductance | ua | microampere |
| $K_L$ | inductive reactance | uf | microfarad |
| C | capacitor | uh | microhenry |
| $X_C$ | capacitive reactance | uv | microvolt |
| Z | impedance | m | milli |
| h | henries (inductance) | Ma | milliampere |
| K | thousand (Kilo-) | MHz | megahertz |
| P | power | mv | millivolt |
| PD | potential difference | mw | milliwatt |
| emf | electromotive force | mh | millihenry |
| kwh | kilowatt-hour | RF | radio frequency |
| A.H. | ampere hour | AM | amplitude modulated |
| Hz | hertz (cycles/second) | FM | frequency modulated |

**ET 101**
**MAINTENANCE OF ELECTRONIC SYSTEMS**
**Schematic Symbols**

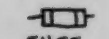
**Information Sheet #4**


+
−
SINGLE CELL
+
−
MULTICELL

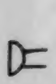
BATTERIES


CHASSIS
EARTH

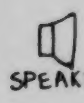
GROUNDS



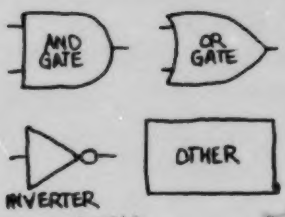
FUSE



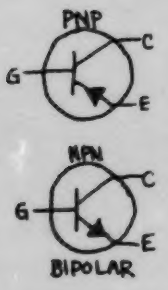
MICROPHONE



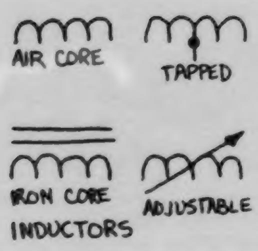
SPEAKER


AND GATE
OR GATE
INVERTER
OTHER

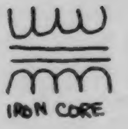
LOGIC


PNP
C
G
E
NPN
C
G
E
BIPOLAR

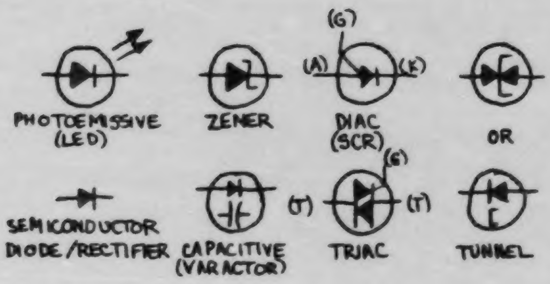
TRANSISTORS


AIR CORE
TAPPED
IRON CORE
ADJUSTABLE

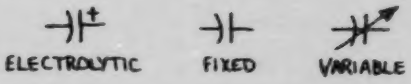
INDUCTORS



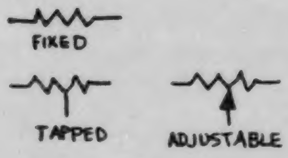
TRANSFORMERS


PHOTOEMISSIVE (LED)
ZENER
(G)
(A)
(K)
DIAC (SCR)
OR
SEMICONDUCTOR DIODE/RECTIFIER
CAPACITIVE (VARACTOR)
(G)
(T)
(T)
TRIAC
TUNNEL

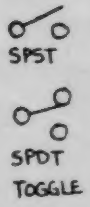
DIODES


+
ELECTROLYTIC
FIXED
VARIABLE

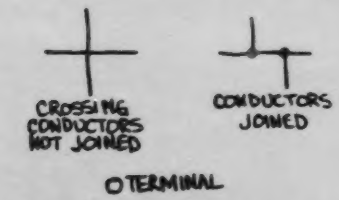
CAPACITORS


FIXED
TAPPED
ADJUSTABLE

RESISTORS


SPST
SPDT
TOGGLE

SWITCHES


CROSSING CONDUCTORS NOT JOINED
CONDUCTORS JOINED
O TERMINAL

WIRING

ET 101
ELECTRONIC MAINTENANCE
THOUGHT PAPER CLARIFICATION

Information Sheet #5

This information is to act as an aid in preparing your thought paper. Each paper is due the Monday following the tour and/or presentation. Please include a copy of previously written papers along with the current assignment.

The following points may be an aid in the production of your next thought paper assignment.

1. Clearly define Electronic Maintenance (Use your prior definition)

2. State what the guest lecturer said, demonstrated or showed that impressed you.

3. Using Step 2, state why or how this information affected your present definition of Electronic Maintenance.

4. State (list) the changes you are making in your definition of Electronic Maintenance.

5. State your new definition of Electronic Maintenance. Support by adding examples that will add meaning and clarify your new definition.

6. Keep typewritten materials within the guidelines of 150-225 words, double spaced.

# ET 101
# ELECTRONIC MAINTENANCE
# MICRO-PROCESSOR PAPER REQUIREMENTS

## INFORMATION SHEET #6

The micro-processor assignment is due on Monday, December 10, 1984. This paper will consist of an indepth report that is typed, double spaced and ranges from 1200 to 1600 words in length. This effort will represent 20% of the course grade.

The content of the paper will address the use of the micro-processor or better known as the home computer in a specific application chosen by the paper's author. Specifically, the author will select an application for computer usage. Describe the application. Determine the hardware and software needs and costs along with the systems cost effectiveness.

Address your comments to these specific topics:

1. What do I want the computer to do.
2. What kind of computer do I need, (portable, handheld, desk, etc.)
3. What software program do I need.
4. What computer can run the software.
5. What are the costs involved in purchasing, renting or leasing the software.
6. How much training is required to use the software, (is it user-friendly)
7. Who answers questions about software problems, (is there software support)
8. Is there a backup copy of the software, free replacement, etc., if the program becomes defective.
9. How do the various computers compare.
10. Is the computer easy to use.
11. How much software is available that may have application to your needs for this specific computer.
12. Will the monitor display what is needed.
13. Can interfaces be added to the computer.
14. How much can the basic computer be expanded.
15. Who repairs the machine. What does it cost.
16. How much memory is needed.
17. How much does extra memory cost.
18. What type of memory device do I need, (cassette tapes, cartridges, Floppy (size) Winchester)
19. What kind of keyboard is needed or desired.
20. What type of display is required.
21. What kind of printer is needed.
22. How much will the printer cost.
23. Is the printer fast enough for my needs.
24. What other type of peripherals are needed.
25. Is the computer capable of supporting them.
26. What costs are involved for the peripherals or for computer modification to make it operational.
27. Do I need to write programs.
28. What language do I know or I am willing to learn.

Additional questions may be added to the provided list. It is important that you address the requested information as this data is required to make an intelligent purchase decision regarding a computer system.

The last portion of the paper will consist of two parts. The first being a cost breakdown of ALL the items required to place the system into operation, training, supplies, etc.; the second being your justification for the use or non-use of the system you chose for your specific application. In essence, do you want to buy the system or not and what do you base that decision on.

ET 101
Electronic Maintenance Technology
COMPUTER TERMS GLOSSARY

Information Sheet #7

## GLOSSARY

Acoustic coupler: A device that allows your home computer to be connected to a remote computer by placing a telephone handset into it.

A/D: Analog-to-digital converter. A device or subsystem tht changes real-world analog data to a form compatible with binary processing.

Address: A character or group of characters that identify a register. A particular part of storage, or some other data source or destination.

Arithmetic logic unit (ALU): The central processing unit chip logic which actually executes the operations requested by an input comand. The ALU is the heart and one of the essential components of the microprocessor. It is the operative base between the registers and control block. The ALU performs various forms of addition and subtraction, and the extension of these to multiplication, division, exponentiation. The logic mode relates to the operations of gating, masking, and other manipulations of the contents of the registers.

ASCII: Specifies which computer code will stand for each character, providing a standard that allows computers from different manufacturers to "talk" to each other.

ASCII code: A code tht relates 96 displayed characters (64 without lower case) and 32 nondisplayed control characters to a sequence of on or off choices.

Assembler: A software program that translates symbolically represented instructions into their binary equivalents.

Assembler language: A language that makes efficient use of memory and creates a program that runs quickly.

Assembly program: A program that translates a program written in pseudo language (symbolic language) to a corresponding program in machine language. Principally designed to relieve the programmer of the task of assigning actual storage locations to instructions and data when coding a program and to permit use of mnemonic operation codes rather than numeric operation codes.

Backup: An extra copy of information stored on a disk or cassette. If the program or other data stored on the first disk or cassette becomes damaged, it is still available on the backup copy.

BASIC: The most commonly used language on home computers.

Baud: A measurement of the rate at which computer information is transferred.

Baud rate: Measurement of data flow in which the number of signal elements per second is based on the duration of the shortest element. When each element carries one bit, the baud rate is numerically equal to bits per second (bps).

BCD (binary coded decimal): A positional value code in which each decimal digit is binary coded into 4-bit "words."

Bidirectional: An interface port or bus line that can be used to transfer data in either direction; for example, to or from the microprocessor.

Binary: A number system using 2 as its base and only the digits 0 and 1.

Bit: A binary digit (1 or 0), the information handled by chips.

Boot: To start up a program.

Bootstrap: A technique or device designed to bring itself into a desired state by means of its own action. A machine routine whose first few instructions are sufficient to bring the rest of itself into the computer from an input device.

Buffer: A device designed to be inserted between devices or program elements to match impedances or peripheral equipment speeds, prevent mixed interactions, supply additional drive or relay capability, or simply delay the rate of information flow; classified as inverting or noninverting.

Bug: An error. A hardware bug is an error in a computer or peripheral. A software bug is a programming error.

Bus: One or more conductors used as a path over which information is transmitted.

Byte: A group of adjacent binary digits processed as a unit. Usually an 8-bit parallel grouping.

Central processing Unit (CPU): The brain of a computing machine. Performs control, input/output, arithmetic, and logical operations by executing instructions obtained from memory sources.

Character: One of a set of elements which may be arranged in ordered groups to express information. Each character has two forms: a man-intelligible form and a computer-intelligible form.

Chip: A single substrate on which all the active and passice elements of an electronic circuit have been fabricated by various semi-conductor technologies.

Clock: A pulse generator that controls the timing of the switching circuits and memory states, thus determining the speed at which the major portion of the computer or timing circuits operate.

Clock/calendar: A circuit or accessory that keeps track of the time and day.

CMOS: Complementary metal-oxide-semiconductor. A technology that uses both P- and N-channel devices on the same silicon substrate.

Command: An instruction that you use to get a computer to do something.

Communications software: Allows computers to "talk" to each other.

Community bulletin board: A dial-up computer used to exchange messages.

Compiler: An automatic computer coding system that generates and assembles a program from instructions written by a programmer or prepared by equipment manufacturers or software companies.

Computer network: Two or more computers connected to exchange information.

Computer program: A series of instructions that tell a computer to do a specific thing or series of things.

Continuous form: Computer paper (not single sheets).

Control bus: A group of bidirectional lines originating either at the CPU or the peripheral equipment used to control transfer or reception of signals to or from the CPU.

CRT: Cathode ray tube. A TV-like device (monitor) used to display information the computer has generated.

Cursor: A position indicator frequently employed in a display on a video terminal to indicate a character to be corrected or a position in which data is to be entered.

Data: Information fed into or out of a computer.

Debouncing: Eliminating unwanted pulse variations caused by mechanically generated pulses when contacts repeatedly make and break in a bouncing manner.

Debug: Using an instruction, program or action designed in microprocessor software to search for, correct or eliminate sources of errors in programs.

Diagnostics: A program that checks the computer for problems.

Digitizer: A device for drawing computer pictures.

Disk drive: A device that can store and retrieve information on a disk.

Diskette: A round piece of magnetic-coated flexible (floppy) plastic, covered by a protective envelope, and used to store data.

Double density: A type of diskette that allows twice as much data to be stored as single density.

Dual drive: Two disk drives in one box.

Dynamic random access memory: A memory device that stores data as charge on a capacitive component and therefore needs refreshing regularly in order to retain its contents.

Editor: A general purpose text editing program used to prepare source program tapes; original text entered via the teletypewriter and held in memory may be changed or corrected.

EEPROM: Electrically erasable programmable read only memory.

EPROM: Erasable programmable read-only memory; ideally suited for uses where fast turnaround and pattern experimentation are important.

Executive routine: A routine designed to control the loading, relocation, execution and possibly the scheduling of other routines; part of the basic operating system that maintains ultimate control of the computer at all times. Control always returns to the executive routine when any controlled routine finishes its functions or when an unexpected stop or trap occurs. Also called supervisory routine, monitor.

Expansion slot: A computer socket to plug in more memory or other devices.

Firmware: Software that has been permanently placed in ROM (read-only memory) chip. Firmware is located inside a computer and in all cartridges.

Flag: A bit or bits stored for later use, indicating the existence of a previous or present condition.

Flip-flop: A circuit having two stable states and two input terminals (or signals) corresponding to each of the two states. The circuit remains in either state until the corresponding signal is applied.

Gate: A circuit having two or more inputs and one output. The output depends on the combination of logic signals at the inputs. The five basig cates are: AND, OR, NAND, NOR, EXCLUSIVE OR.

Handshaking: Electrical provision for verification that a proper data transfer has occurred. A data-ready/data-received signal scheme that assures orderly data transfer.

Hard disk: A disk drive capable of storing millions of bytes of data.

Hardware: The actual computer equipment, as opposed to "software."

Help screen: "Help" explanations included in a software package.

Hexadecimal: Base-sixteen number system.

Impact printer: A printer that prints by impacting (hitting) a character against the paper.

Input/output device: Computer hardware capable of entering data into a computer or transferring data from a computer; abbreviated I/O.

Instruction: Information that, when properly coded and introduced as a unit into a digital computer, causes the computer to perform one or more of its operations; commonly includes one or more addresses.

Integrated circuit: An interconnected array of conventional components fabricated on and in single crystal of semiconductor material by etching, doping, and diffusion, and capable of performing a complete circuit function.

Joystick: A game controller that moves an object around on the screen.

K: Kilobyte, approximately 1000 bytes, or characters of data.

Large-scale integration (LSI): The accumulation and design of a large number of circuits (1000 or more) on a single semiconductor chip.

Light pen: A high speed, photosensitive device that can cause a computer to change or modify the display on the cathode-ray tube.

Logic analyzer: A device used in the first steps of troubleshooting - locating the problem by examining the sequence of events leading up to a failure.

Loop: A sequence of instructions that is written only once but executed many times (iterated) until some predefined condition is met.

Low level language: A language close to the machine code of a computer whose instructions usually bear a one-to-one relationship with the machine code.

Machine language: The basic binary code used by all computers. It can be written in either hexadecimal or octal.

Mainframe: A large computer.

Memory: A storage device into which information can be inserted and held for use at a later time.

Menu: A list of choices that you have in a program.

Microcomputer: A complete computing system, consisting of hardware and software, whose main processing blocks are made of semi-conductor integrated circuits.

Microprocessor: The semiconductor central processing unit (CPU) and one of the principal components of the microcomputer.

Mnemonics: A programming short-hand using letters, numbers, and symbols adopted by each manufacturer to represent the instruction in his instruction set.

Modem: A MOdulator/DEModulator device that converts signals in one form to another kind of equipment. In particular, the device that changes digital data to a form suitable for computers and terminals to communicate over telephone lines.

Monitor: A TV-like computer display with better resolution than a TV set.

Nonvolatile: A memory type that holds data even if power has been disconnected.

Octal: Base-eight numbering system.

Parity: A binary digit appended to an array of bits to make the sume of all the bits always odd or even. A method for checking the accuracy of transmitted or transferred binary data.

Peripheral: A piece of equipment that is external (peripheral) to the computer itself (disk drives, printers, etc.)

Peripheral equipment: Units that work in conjunction with a computer but are not a part of it, for example a tape reader, analog-to-digital converter, typewriter.

Pixel: The smallest picture element (dot) on a computer screen. A measure of resolution.

Plotter: A device that draws a picture.

Port: An electrical logic circuit configuration that is a signal input or output access point the microprocessor bus system.

Printer: A device that produces a printed (hard) copy of data generated by the computer.

Program: A set of instructions arranged in a proper sequence for directing a digital computer in performing a desired operation or operations.

Programmable: That characteristic of a device that makes it capable of accepting data to alter the state of its internal circuitry to perform two or more specific tasks.

Programmed I/O: The control of data flow in and out of the microprocessor completely under software direction. It implies a lack of independent port activity.

Programmer: A person who writes (creates) program.

PROM: Programmable read only memory. A semiconductor diode array that is manufactured with a pattern of either all 1s or all 0s and is user programmed by fusing or burning out diode junctions.

RAM: Random access memory. Provides immediate access to any storage location point in the memory by means of vertical and horizontal coordinates. Information may be written in or read out in the same very fast procedure.

Real time: The performance of computation during the actual time that the related physical process transpires so that results of the computation can be used in guiding the physical process.

ROM: Read only memory. A nonvolatile memory device programmed by a mask pattern as part of the final manufacturing stage. Information is stored permanently or semi-permanently and is read out but not altered in operation.

RS-232C: A type of connection (used with serial interfaces).

Save: To store a program on a disk or cassette.

Scratchpad: A nickname for CPU memory that pertains to information the CPU holds temporarily. RAM or registers that are used to store temporary, intermediate results (data) or memory addresses (pointers).

Single density: A type of diskette that allows half as much data to be stored as double density.

Software: Programs, languages and procedures of a computer system.

Time-sharing: A computing technique allowing more than one terminal device to use the input, processing and output facilities of a central computer simultaneously.

Transducer: A device that converts something measurable, often a physical property such as pressure, temperature, or flow, into another form such as an electrical signal.

UART: Universal asynchronous receiver/transmitter. In a UART, the transmitter converts parallel data bits into serial form for transmission; the receive section does the reverse operation.

User-friendly: Easy to use.

VLSI: Very large scale integration.

Wire wrap: An alternative to soldering, consisting of winding a number of turns of wire around a metal post that has at least two sharp edges.

Word: A group of characters occupying one storage location in a computer and treated by the computer circuits as an entity, by the control unit as an instruction and by the arithmetic unit as a quantity.

Write: The process of sending data to an external storage device or system. To record information in a register, location or other storage device or medium.

# ET 101
# ELECTRONIC MAINTENANCE
# FINAL STUDY GUIDE

## INFORMATION SHEET #8

Microfarad
Binary Information
Inputs
User-Friendly
Joystick
Cursor
Thermal Printer
Resistance
Data
Transistor
Floppy Disk
High Resolution
Cassette Tape
Hard Disk
Binary Word
Address
Bus
System Timing
Resistor
ROM
Computer Operating System
IBM Compatible
Hard Disk
DOS
Microprocessor
Software
Hardware
Nonvolatile
Disk Drive
Microcomputer
A/D
RAM
Air Inductor
Outputs
Home Management
Current
PROM
Daisywheel
Friction Feed
Command
Binary
Alternating Current
Bootstrap
Voltage
Clock
IEEE-488
Battery
Assembler
LCD
Basic
Menu
Membrane
Capacitor
Dot Matrix
Accumulator
Pin Feed
Processor
EPROM
Microprocessor Chip
Instruction Codes
40 Columns
Portable Computer
ASC II
Word Processing
Entertainment Computer
Power
Bidirectional
Memory
RS-234C
CPU
Bug
Ohms
Kilohertz
DC
Megahertz
Keyboard
Expansion Slot
QWERTY
Business Software
Baud
80 Columns
Modem
Program Counter
Real Time
ALU

Final is composed of:

| | |
|---|---|
| True of False | 21 |
| Multiple Choice | 13 |
| Short Answer Fill-in | 20 |
| Matching | 28 |

# ET 101
# Electronic Maintenance
# STUDY GUIDE
# TEST #1

INFORMATION SHEET #9

Test #1 will consist of a total of 82 points of which 26 points are true/false and 56 points are fill-in the blanks.

Identify resistor values (4 points)
Red Red Red Gold 2.2 k ohm

Resistor tolerance (3 points)
Red Orange Orange Silver 20.7k ohm 25.3k ohm

Perform the conversions (4 points)
4,626 mA 4.626 Amps

Identify abbreviations (7 points)
mA milliamps

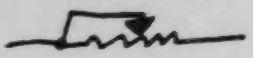
Convert to scientific notation (5 points)
186,746 $1.86746 \times 10^5$

Convert from power of tens to units (5 points)
$7 \times 10^2$ .07

Indicate the power of ten associated with each prefix (5 points)
Kilo $10^3$

Convert to the proper units (5 points)
2,200 ohms 2.2k ohms

Draw symbols (8 points
Rheostat



Terms--know what they mean

DVM
VOM
DMM
AM
Analog
DC meter
Diode
LED

DC
SPST
RF
DPST
Digital
Rectifier
Steady State Signals
Transistor

Time Varying Signals
Capacitor
Inductor
Resistor
Tolerance
EMF
Switch
Pot

Equipment--know what it does and its advanatages and disadvantages

Frequency Counter
VOM
Oscilloscope
Power Meter (RF)

Spectrum Analyzer
DVM/DMM
Watt Meter

### ET 101
### ELECTRONIC MAINTENANCE
### CONVERSIONS

ASSIGNMENT #1
15 points

Name ____________________

Perform the conversions:

1. 0.15 μsec = __________ nsec

2. 185 μa = __________ mA

3. 150 μW = __________ mW

4. 1.5 MHz = __________ kHz

5. 210 mA = __________ μA

6. 0.012 μF = __________ pF

7. 147,000 Ω = __________ MΩ

8. 21,000 pF = __________ μF

9. 47,000 Ω = __________ KΩ

10. 830 kHz = __________ MHz

11. 680 mV = __________ V

12. 4.7 V = __________ mV

13. 14 kW = __________ W

14. 2150 μ℧ = __________ ℧

15. 0.33 MΩ = __________ kΩ

### ET 101
### ELECTRONIC MAINTENANCE
### POWER OF TEN

ASSIGNMENT #2
30 points

Name ______________________

1. Convert to scientific notation (powers of 10). (11 points)

(a) 1750 ____________________

(b) 4.717 ____________________

(c) 470,000 ____________________

(d) 0.0004 ____________________

(e) 16,000 ____________________

(f) 0.00012 ____________________

(g) 0.1817 ____________________

(h) 0.121,000,000,000 ____________________

(i) 0.000,000,000,075 ____________________

(j) 0.72 ____________________

(k) 1,210,000 ____________________

2. Perform the required multiplication. Respond in powers of 10. (6 points)

| PROBLEM | POWER OF TEN |
|---|---|
| (a) 223,000 x 1,020,000 | ______________ |
| (b) $(1.7 \times 10^5)(2.4 \times 10^6)$ | ______________ |
| (c) $(7.8 \times 10^7)(5.1 \times 10^4)$ | ______________ |
| (d) $(1.7 \times 10^{-3})(2.1 \times 10^{-5})$ | ______________ |
| (e) $(6.2 \times 10^{-4})(7.9 \times 10^{-2})$ | ______________ |
| (f) $(1.7 \times 10^{-9})(7.4 \times 10^6)$ | ______________ |

3. Divide the following, place answers in powers of 10. (8 points)

(a) $\frac{310,172}{97}$ ____________________

(b) $\frac{2.6 \times 10^{7}}{3 \times 10^{-4}}$ ____________________

(c) $\frac{18 \times 10^{7}}{4 \times 10^{3}}$ ____________________

(d) $\frac{0.0027}{0.0007}$ ____________________

(e) $\frac{6 \times 10^{14}}{3 \times 10^{3}}$ ____________________

(f) $\frac{8 \times 10^{-11}}{15 \times 10^{2}}$ ____________________

(g) $\frac{5 \times 10^{7}}{.0025}$ ____________________

(h) $\frac{31,300}{100}$ ____________________

4. The value of the following prefixes in powers of 10 are: (5 poin[illegible])

| Prefix | Power of 10 |
|---|---|
| kilo | |
| Micro | |
| Mega | |
| Milli | |
| pico | |

## ET 101
## ELECTRONIC MAINTENANCE
## COLOR CODE

ASSIGNMENT #3
80 points

Name ______________________________

Using the indicated resistance bands, determine the resistors value in the specified units, the resistors tolerance in percentage and the resistors minimum and maximum value based on its tolerance. (One point for each correct answer)

| | | | | | Value | Tolerance | MIN | MAX |
|---|---|---|---|---|---|---|---|---|
| 1. | Orange | Orange | Red | Gold | 3.3 k | 5% | | |
| 2. | Brown | Green | Yellow | | k | | | |
| 3. | Green | Blue | Green | Silver | M | | | |
| 4. | Blue | Gray | Brown | Silver | Ω | | | |
| 5. | Yellow | Violet | Orange | | k | | | |
| 6. | Brown | Green | Green | | M | | | |
| 7. | Red | Violet | Orange | Gold | k | | | |
| 8. | Gray | Red | Yellow | Gold | k | | | |
| 9. | Red | Red | Red | Silver | k | | | |
| 10. | Gray | Red | Black | Gold | Ω | | | |
| 11. | Orange | Orange | Green | | M | | | |
| 12. | Brown | Red | Brown | Gold | Ω | | | |
| 13. | Blue | Gray | Yellow | Gold | k | | | |
| 14. | Brown | Black | Green | Gold | M | | | |
| 15. | Orange | White | Red | | k | | | |
| 16. | Red | Red | Orange | | k | | | |
| 17. | Orange | Orange | Orange | | k | | | |
| 18. | Yellow | Violet | Black | | Ω | | | |
| 19. | Red | Violet | Gold | Gold | Ω | | | |
| 20. | Brown | Black | Blue | Silver | M | | | |

# ET 101
# ELECTRONIC MAINTENANCE
# RESISTOR UNITS

ASSIGNMENT #4
40 points

Name ____________________________

In Assignment #3 the symbols k, M and Ω were used to indicate the resistors value in the industrial accepted form. In the following, indicate the value of the resistor along with the proper units of k, M, or Ω. (One point for each correct value and symbol)

| | | | | Value | Units |
|---|---|---|---|---|---|
| 1. | Orange | Black | Green | 3 | M |
| 2. | Yellow | Violet | Red | | |
| 3. | Yellow | Violet | Green | | |
| 4. | Gray | Red | Red | | |
| 5. | Orange | Orange | Gold | | |
| 6. | Brown | Red | Orange | | |
| 7. | Green | Blue | Yellow | | |
| 8. | Red | Red | Brown | | |
| 9. | Brown | Black | Orange | | |
| 10. | Blue | Gray | Green | | |
| 11. | Orange | Orange | Black | | |
| 12. | Red | Red | Yellow | | |
| 13. | Blue | Gray | Red | | |
| 14. | Brown | Black | Red | 1 | k |
| 15. | Green | Blue | Red | | |
| 16. | Brown | Red | Green | | |
| 17. | Red | Violet | Black | | |
| 18. | Brown | Black | Yellow | | |
| 19. | Orange | White | Green | | |
| 20. | Brown | Gray | Gold | | |

# ELECTRONIC MAINTENANCE TECHNOLOGY PROGRAM

## BASIC ELECTRONICS

## PS 170

Learning for a Lifetime

WASHBURN UNIVERSITY
School of Applied and
Continuing Education

# ELECTRONIC MAINTENANCE TECHNOLOGY PROGRAM
PS 170
BASIC ELECTRONICS

SCHOOL OF APPLIED AND CONTINUING EDUCATION
WASHBURN UNIVERSITY

# FORWARD

In 1983, the Vocational Administration Section of the Kansas State Department of Education provided a grant to the School of Applied and Continuing Education at Washburn University to develop a two year associate degree program in the emerging high technology field of electronics. These curriculum materials are one of the products of that project. This curriculum package includes the course syllabi, study guide, information sheets, laboratory sheets, assignments sheets and unit examinations.

The materials in this package have been prepared in a sequence that best matched our situation. The individual instructor may add, delete or rearrange to his/her own needs.

Assistant Professor, Jim Jaworski is the author of these curriculum materials and is to be congratulated for his work. Our special thanks also go to the support staff in the School for their assistance with graphics, typing and editing of these materials.

William S. Dunlap

and

Reid A. Holland
Project Directors

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State Reference No. 85-132-03

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PS 170
BASIC ELECTRONICS
4 Semester Hours
School of Applied and Continuing Education
Washburn University
Fall 1984
J. Jaworski, Professor

## INTRODUCTION

The study of Electronic concepts is a fascinating and interesting subject area. This course will explore the fundamental concepts basic to electronic circuitry through the use of lectures, demonstrations and lab projects. Concepts ranging from resistance through reactance to current through capacitance will be covered. The emphasis will be placed on obtaining a functional literacy in the use of electronics - a skill that has value outside the classroom.

## COURSE ORGANIZATION

The class will meet twice a week. On Tuesday evening, the class runs from 6:45 to 9:35 p.m. On Thursday evening, the class is in session from 6:45 to 8:45 p.m. Lecture and lab sessions will be interchanged at the discretion of the instructor to best facilitate the presentation of course material.

## COURSE CONTENT

The material covered in this course will basically follow the below listed chapters/topics.

Chapter 1. Current & Voltage
2. Resistance
3. Ohm's Law
4. Series & Parallel Networks
5. Complex Circuit Analysis
6. Thevenin's Theorem
7. Measuring Time Varying Signals
8. Capacitor's
15. Impedance & Phase
16. Analyzing AC Networks
12. Unregulated Power Supplies

## COURSE OBJECTIVES

The objectives of this course are adequately stated at the beginning of each chapter in your textbook. These objectives reflect the needs and desired outcome of this course.

## COURSE REQUIREMENTS

Text: McWane, John, Introduction to Electronics and Instrumentation

## GRADING SCALE

All class evaluation will be based on the grading scale listed below. The indicated percentge designates the bottom of the respective grade zone, i.e., 85% is the bottom of the B's. An individual earning an 84% would receive a grade of C, etc.

| | |
|---|---|
| A | 93% |
| B | 85% |
| C | 77% |
| D | 69% |

Individual grades will not be issued during the course of the term. It is your responsibility to record all test scores and calculate any applicable letter grades. As an example: a test has 86 possible points. Your score is 76. Divide 76 by 86 and the percentage is 88.4%. The equivalent letter grade from the chart is a grade of "B".

## EVALUATION
(50% of the total grade)

All major evaluations will contribute an equal percentage regardless of the number of evaluations during the course of the term. The number of evaluations may range from two through four with the following table listing the applicable percentages:

| | |
|---|---|
| Two Evaluations | 25.0% each |
| Three Evaluations | 16.6% each |
| Four Evaluations | 12.5% each |

The Final Examination will be given as listed in the fall schedule of classes. The Final Examination date and time is: Thursday, December 20, 1984, beginning at 6:45 p.m. and ending at 9:30 p.m.

## EVALUATION REVIEW PROCEDURES

The following procedures will be utilized for the review of all major evaluations:

1. Answers will be given in class to check for mechanical grading errors. Comments regarding the agreement or disagreement to a response will not be invited at this time.

2. If a disagreement exists, follow the procedure below:

   A. On the top of the front page of the test, write the number of the question you disagree with.

   B. Locate the page on which the question you disagree with appears. On the back of this page, write your reasons why your response should be considered correct.

   C. Repeat this procedure as often as necessary.

3. Sufficient time will be provided for the individual accomplishment of step two. Those not wishing to respond are to remain silent during this period. There is to be no discussion during this period by any class members.

4. After completion of all written input, the examination will then be reviewed. All responses made during this review process will not have any bearing on any individual's grade, as only the written response will be considered.

5. During this discussion period, all writing on the examination must cease. Those continuing to respond will be considered to be cheating.

6. Individuals not participating in the test review procedures forfeit their right to alter their test score at a future date, i.e. all debate must be made in writing on the test itself.

7. Examination papers will be made available for review purposes on an individual basis. These test materials are not to leave the Instructor's office.

### LAB SHEETS
(20% of the total grade)

Laboratory experiments requiring the gathering of data through the use of electronic instrumentation or the performance of a skill in an instructor - assigned learning experience in student pairs are considered to be lab work.

### ASSIGNMENT/PROBLEM SHEETS
(20% of the total grade)

Individually performed instructor assigned exercises requiring the mathematical manipulation of factors for the obtainment of correct responses, i.e., materials not requiring the use of the lab or lab experiments for the obtainment of answers.

### SENSATIONALS AND HOW ABOUTS
(10% of the total grade)

An individually prepared hand-in covering sensationals and how abouts on class activities, lecture material, reading, discussion, etc.

A sensational is a reaction to a main point or topic that the individual found exceptional or sensational in nature. A how about is a questioning reaction to presented material. How abouts indicate points that are unclear and require further discussion for clarification or offers constructive alternatives to what was presented.

### QUIZZES
(Part of the S and HA total)

Quizzes are considered to be short announced or unannounced examinations consisting of ten to twenty-five points and spaced spasmodically throughout the course. In addition, quizzes can NOT be made up. Generally, a missed quiz will result in a grade of zero being entered into the record for that particular quiz. However, each individual is allowed to miss one quiz without penalty.

## LATE POLICY

In general, materials to be handed in are due at the beginning of the class period. These materials are considered late if presented after the announced due date unless otherwise specified. Materials received late will not be graded.

If you anticipate being absent, these materials may be handed in early, delivered to my office (Room 124, Benton Hall), placed in my faculty mailbox, or presented by a fellow student during the regularly scheduled class period.

## WORK MISREPRESENTATION

All work produced is expected to be your own material. Plagiarism, cheating, or other forms of academic dishonesty are not tolerated. Those being observed in such circumstances will not receive credit for the course.

The instructor reserves the right to alter this syllabus as required.

PS 170
BASIC ELECTRONICS
MATHEMATICS

EXAM #1
68 points

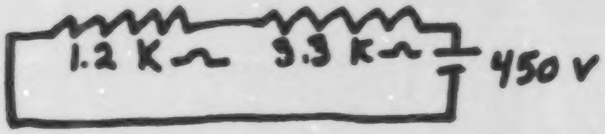
Name ______________________________

DIRECTIONS: Place the requested response in the provided blanks. Show all work used to arrive at your answer. This includes the basic formula, the substitution of numbers into the formula and the steps/procedures used to arrive at your response. One point will be deducted from each response if work is not shown. Work may be done on the back of each sheet, if desired.

All responses must be in correct values and labeled as to the unit the number represents, i.e., .152 A is incorrect; 152 mA is correct. One point will be deducted from each response with incorrect values. Responses with missing or incorrectly labeled unit values (ohm, volts, amps, etc.) will be marked totally wrong, i.e., 250 is incorrect; 250 volts is correct.

EXAMPLE:

$R_t = 1.2\,K\Omega + 33\,K\Omega = \underline{4.5\,K\Omega}$



$I = \frac{E}{R}\ \frac{450V}{4500\Omega} = .1A = \underline{100\,mA}$

4.5 kΩ = R total

100 mA = I TOTAL

1. Three resistors are connected in series across a 294 volt battery.
2. The values of the resistors are 2.7 k ohm, 120 k ohm and 820 ohm. Find the total resistance. (2 points)

____________________ = R total

3. Four resistors each 12 k ohm in value are connected in parallel across
4. a 120 v line. Find the total resistance. (2 points)

____________________ = R total

5. Five resistive loads are connected in parallel. Their values are:
6. 560 ohm at 50 wats, 1.8k ohm at 25 watts, 2.7k ohm at 10 watts, 750
7 ohm at watts, and 910 ohm at 30 watts. Determine the total resistance
8 and the total power dissipated in the circuit if the source is a 255 volt battery. (4 points)

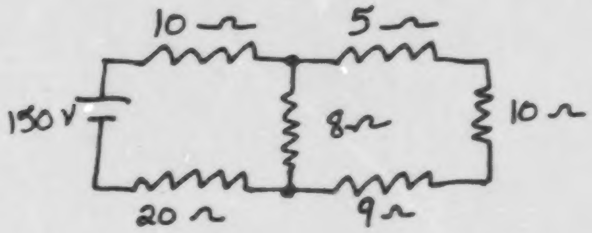
____________________ = R total

____________________ = P total

9. Three resistors of 12, 18, and 47 ohm are connected in series across
10. a 12 volt battery. If the current through the circuit is 153 mA, what is the resistance of the connecting wires. (2 points)

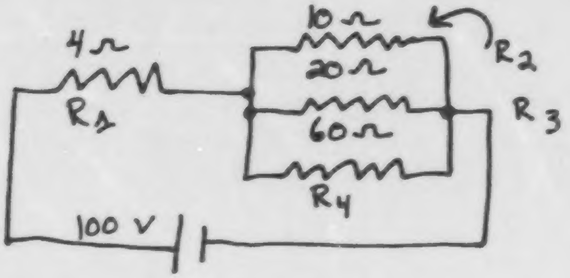
____________________ = R of connecting wire

11.
12.



____________________ = R total (2 points)

13.
14.
15.
16.
17.
18.
19.
20.



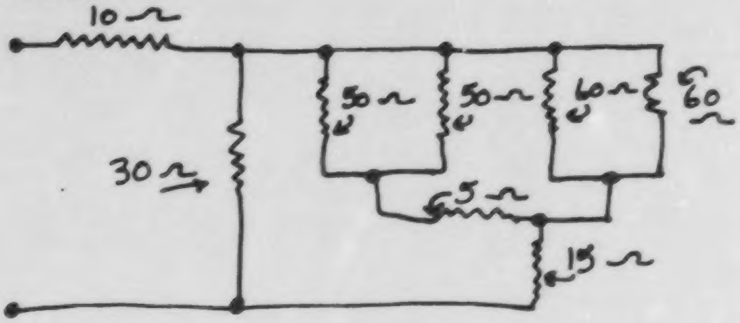
____________________ = R total

____________________ = I total

____________________ = I through $R_4$

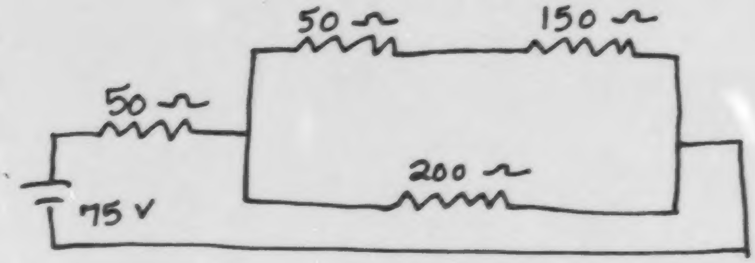
____________________ = E across $R_1$

21.
22.
23.
24.


10 Ω
50 Ω
50 Ω
60 Ω
60 Ω
30 Ω
5 Ω
15 Ω

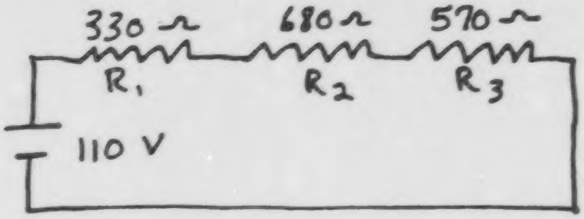
______________________ = R total (4 points)

25.
26.


50 Ω
150 Ω
50 Ω
200 Ω
75 V

______________________ = R total (2 points)

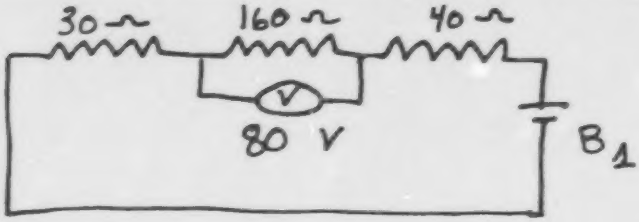
27.
28.
29.
30.
31
32.


330 Ω
680 Ω
570 Ω
R1
R2
R3
110 V

______________________ = I total

______________________ = Voltage across $R_2$

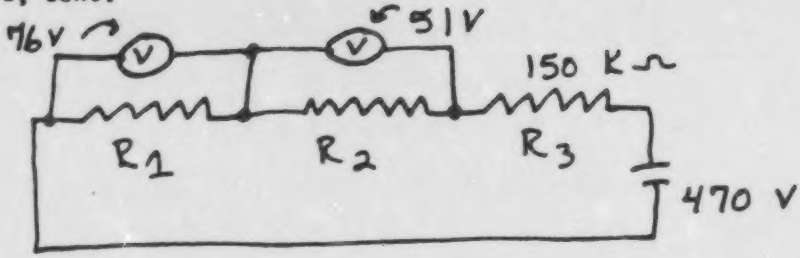
33.
34.
35.
36.


30 Ω
160 Ω
40 Ω
V
80 V
B1

______________________ = I total

______________________ = $B_1$ voltage (4 points

37.
38.
39.
40.
41.
42.

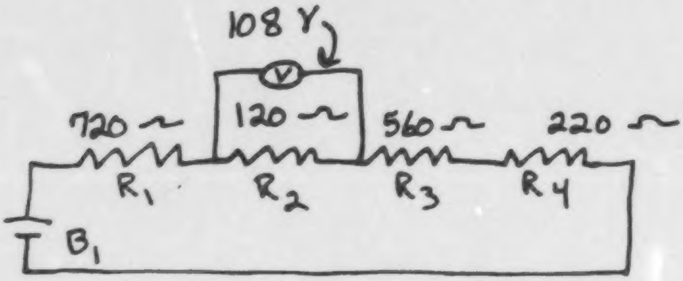

76V
V
V
51V
150 KΩ
R1
R2
R3
470 V

________________ = I total

________________ = $R_1$

________________ = R total (6 points)

43.
44.
45.
46.
47.
48.

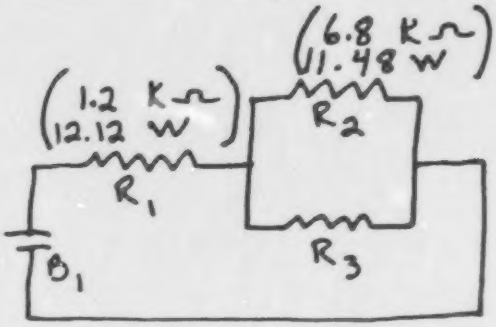

108 V
V
720 Ω
120 Ω
560 Ω
220 Ω
R1
R2
R3
R4
B1

________________ = $B_1$ voltage

________________ = I total

________________ = Power dissipated by $R_4$

49.
50.
51.
52.
53.
54.
55.
56.
57.
58.
59.
60.


6.8 KΩ
11.48 W
1.2 KΩ
12.12 W
R2
R1
R3
B1

________________ = I total

________________ = $B_1$

________________ = $R_3$

________________ = R total

(12 points)

61. The resistance of 90 feet of wire is found to be 32.1 ohms. A coil
62. wound with identical wire has a resistance of 702 ohms. What is the
length of the wire on the coil. (2 points)

____________________ = wire length

63. A voltmeter has an internal resistance of 220k ohms. How much power
64. does it use when the meter reads 110 volts? (2 points)

____________________ = Power

65. A 0-1mA meter has an internal resistance of 53 ohms. What shunt
66. resistance is required to extend the meter range to 0-50mA? (2 points)

____________________ = shunt resistance

67. It is desired to wind a milliamp meter shunt having a resistance of
68. 4.62 ohms. A number 40 copper wire with a resistance of 3.54k ohms
per 1000 feet is available. What is the length of the coil (wire)
needed for the meter shunt? (2 points)

____________________ = coil (wire) length

# PS 170
## Basic Electronics
## Final Part I

130 points

Name______________________________

Section #1 TRUE or FALSE (56 points)

The following statements are either true or false. Indicate the most correct response by circling either the T or F.

T F 1. A sine wave is composed of an infinite number of instantaneous voltage values.

T F 2. An ohmmeter connected across an open component will indicate an infinite resistance.

T F 3. The resistance of an insulated wire is determined by the wires length, resistivity, temperature, and type of insulation.

T F 4. Kirchoff's voltage law states that the sum of the voltages around any closed loop in a circuit must be zero.

T F 5. The voltage drop across a resistor in a series resistive circuit is directly proportional to the resistors resistance value.

T F 6. An electron is a negatively charged particle which orbits the nucleus of an atom.

T F 7. A sine wave must always start at a positive half cycle.

T F 8. As the frequency decreases capacitive reactance decreases and current increases.

T F 9. Alternating current periodically changes amplitude without changing direction.

T F 10. Self induction is the process of producing a counter EMF in a conductor.

T F 11. An inductor does not dissipate any power. It is the resistive element that causes power to be dissipated.

T F 12. The difference between Norton's and Thevenin's theorem is that in the Norton's equivalent circuit, the current source has replaced the Thevenin's voltage source and the equivalent resistance is in parallel with the current source instead of in series with the voltage source.

T F 13. The effective value of an AC waveform is the root of the mean-squared value.

T F 14. The DMM uses an ohmmeter scale that has linear divisions.

T F 15. Another term for a junction of wires is a node.

T F 16. In a parallel resistive circuit, the total resistance is less than the resistance of the smallest branchs.

T F 17. A 2 watt carbon composition resistor is physically small than a 1/4 watt carbon composition resistor.

T F 18. The ohmmeter scale decreases its resistance from right to left on the VOM.

T F 19. Capacitors dissipate power in the form of heat as the electrostatic field alternates between half-cycle power points.

T F 20. An AC generator produces a voltage that increases according to the sine of the angle of rotation.

T F 21. Mutual inductance refers to the ability of inductors to influence the magnetic fields of one another in either an adding or an opposing mode.

T F 22. The resistance of a wire is directly proportional to its length.

T F 23. In a series of RC circuit the voltage drop across the capacitor is a function of the current flowing through the circuit and the value of the capacitance reactance.

T F 24. Resistors in parallel in an AC circuit produce a phase relationship dependent upon the values of the parallel resistive elements.

T F 25. In a series LC circuit when $X_L$ equals $X_C$, the circuit is said to be at resonance.

T F 26. An insulator restricts the flow of electrons.

T F 27. The voltage drop on each branch of a parallel resistive circuit equals the sum of the voltage drops across each parallel branch.

T F 28. Current in a series resistive circuit is inversely proportional to the total voltage and is directly proportional to resistance.

T F 29. A VOM ohmmeter scale is linear in that equal division mean equal changes in resistance.

T F 30. A potentiometer is considered to be a 3 terminal device where as a rheostat is a 2 terminal device.

T F 31. The voltage induced in a conductor is not directly proportional to the rate at which the conductor cuts the magnetic lines of force in a generator.

T F 32. The resistance of a wire is directly proportional to its cross-sectional area.

T F 33. Power in an AC resistive circuit is released in the form of heat as it is in a DC resistive circuit.

T F 34. The applied voltage in a series RC circuit is in phase with the voltage across the capacitor.

T F 35. The same rules that apply to series DC circuits apply to series AC circuits containing capactive elements only.

T F 36. A 37.5 ohm resistor can be replaced by a 100 ohm and a 60 ohm resistor in parallel.

T F 37. The law of conservation of charge basically states, what goes in must come out.

T F 38. Total power in a series resistive circuit equals the sum of all the individual powers.

T F 39. The rise time of a pulse is that time required to go from 90% to 10% of the final pulse height value.

T F 40. It is correct procedure to measure the value of a resistance in a circuit that is energized with a VOM.

T F 41. A linear pot changes its resistance in proportion to its shaft rotation.

T F 42. A number 36 wire is larger in diameter than a number 14 wire.

T F 43. A counter EMF in a conductor will be produced as long as current continues to either increase or decrease.

T F 44. Because of the unique relationship between current and voltage in a AC resistive circuit the power formulas that apply to a DC resistive circuit can not be used in an AC resistive circuit.

T F 45. Each resistor added to a series AC circuit increase the phase shift by the sine of the angle of the applied voltage.

T F 46. In a series AC resistive circuit the sum of the resistive voltage drops equal the applied voltage.

T F 47. A sine wave is composed of one positive half cycle and one negative half cycle.

T F 48. It is important to observe polarity when connecting the leads of an ohmmeter when measuring an unknown resistance.

T F 49. The branch of a parallel resistive circuit that has the least resistance has the greatest current flow and dissipates the greatest amount of power.

T F 50. Adding a branch to a parallel resistive circuit causes the total resistance to increase and the total current to decrease.

T F 51. Gold is a better conductor than copper.

T F 52. The current will always lead the voltage in a series RC circuit by less thatn 90°.

T F 53. As the value of a capacitor increases, capacitive reactance decreases, and current increases.

T F 54. The direction of movement of a wire in a magnetic field determines the polarity of the induced voltage.

T F 55. In a series RC circuit the larger the $X_C$ in relation to the resistance, the greater the phase shift.

T F 56. The larger the distance between the plates of a capacitor the greater the capacity. (ability to store electrons)

Section #2 MULTIPLE CHOICE (30 points)

Indicate the most correct response by circling the statement number of your choice.

57. A sequence of pulses occuring in succession is called a

1 modulated signal
2 periodic signal
3 pulse train
4 duty cycle
5 period

58. The process of inducing a voltage within a wire that is moving through a magnetic field is the definition of:

1 Kirchoff's current law
2 phase differential
3 slew rate
4 electromagentic induction
5 step signals

59. The peak to peak value of an AC waveform is 65 volts. Its RMS valve is:

1 91.937 volts
2 45.968 volts
3 41.275 volts
4 22.977 volts
5 20.637 volts

60. One cycle of an AC waveform is

1 15°
2 90°
3 180°
4 270°
5 360°

61. The unit of measure for capacitance is the:

1 Henery
2 Farad
3 Ohm
4 Capacitance reactance
5 Coulomb

62. The algebraic sum of all the voltages around any closed path equals zero is the definition of:

1 voltage law
2 current law
3 Superposition theorem
4 Thevenin's theorem
5 Millman's theorem

81

63. The slew rate of a signal is defined as:

1 the rate at which a signal changes
2 the peak to peak signal amplitude
3 the RMS signal value
4 the amount of signal ringing
5 the rate of rise time rise.

64. The algebraic sum of the currents into any point of a circuit must equal the algebraic sum of the currents out of that point is the definition of:

1 voltage law
2 current law
3 Millman's theorem
4 Thevenin's theorem
5 Norton's theorem

65. A resistor is color coded violet, green, orange, silver. Its value is:

1 47,000 ohms
2 75,000 ohms
3 7.5k ohms
4 75k ohms
5 75k ohms ± 10%

66. The amount of voltage induced in a wire in a generator is determined by:

1 the angle at which the conductor cuts the lines of force.
2 the polarity of the magnetic field
3 the direction of current movement
4 the number of slip rings and brushes
5 the size of the load

67. A parallel resistive AC circuit behaves in the same manner as a:

1 DC resistive circuit
2 series DC resistive circuit
3 capacitve parallel DC circuit
4 inductive series AC circuit
5 capactive series AC circuit

68. The unit of measure for inductance is the:

1 Henery
2 Farad
3 ohm
4 inductive
5 coulomb per second

69. A meter is used to measure the number of coulombs in a circuit. The meter used for this purpose is called a/an:

1 voltmeter
2 ampmeter
3 ohm meter
4 watt meter
5 power meter

70. Which one of the below is classified as an insulator under normal conditions.

1 gold
2 germanium
3 silicon
4 glass
5 steel

71. A capacitor has a voltage drop of 10 volts. A resistor has a voltage drop of 5 volts in a series RC circuit. It can be said that the phase angle is

1 less than 10°
2 greater than 80°
3 equal to 45°
4 greater than 50°
5 less than 30°

72. In a series RC circuit

1 the voltage across the resistor is out of phase with the current
2 the voltage across the capacitor lags the current by 90°
3 the voltage drop across the capacitor is in phase with the current through the capacitor
4 the current through the resistor lends the voltage by 90°
5 the current in the circuit is out of phase with the voltage across the resistor

73. Any linear 2 terminal network can be represented by an electrically equivalent circuit consisting of 1 voltage source in series with a resistance is the definition of:

1 Voltage law
2 Superposition theorem
3 Maximum voltage transfer theorem
4 Thevenin's theorem
5 Norton's theorem

74. In a pure AC inductive circuit:

1 current and voltage are in phase
2 current lags the voltage by 90°
3 voltage lags the current by 90°
4 current leads the voltage by 90°
5 the induced voltage is greater than the applied voltage.

75. A capacitor is a device that

1 is composed of 2 plates separated by a conductor
2 dissipates a stored charge
3 opposes a change in current
4 stores electrical energy in its electrostatic field
5 dissipates energy in the form of power

76. The peak value of an AC waveform is 80 volts. Its peak to peak value is:

1 40 volts
2 50.88 volts
3 56.56 volts
4 113.12 volts
5 160 volts

77. A pulse has a width of .05 seconds with a period of .21 seconds. The duty cycle for this waveform is:

1 .238
2 2.38%
3 4.2
4 23.809%
5 42%

78. An AC circuit containing a single resistor will have which one of the following characteristics?

1 The voltage is minimum when the current is maximum
2 The current leads the voltage by 45°
3 When the voltage is zero the current is zero
4 The current is minimum when the voltage is maximum
5 Current leads voltage by 90°

79. An inductor has a voltage drop of 40 volts. A resistor has a voltage drop of 20 volts in the same series RC circuit. It can be said that the phase angle is:

1 less than 10°
2 less than 30°
3 equal to 45°
4 greater than 50°
5 greater than 80°

80. The graticule on front of the CRT is marked off in squares. The size of each square is:

1 1 inch by 1 inch
2 1 meter by 1 meter
3 .5 inch by .5 inch
4 1 cm by 1 cm
5 .5 cm by .5cm

81. The quantity that spefies the relative electrical resistance of a material is called:

1 resistivity
2 conductance
3 Mho
4 transconductance
5 impedance

82. Any linear two-terminal network can be represented by an electrically equivalent circuit consisting of one current source and one parallel impedance (resistance) is the definition of:

1 current law
2 Norton's theorem
3 Tuperposition theorem
4 Therenin's theorem
5 Millman's theorem

83. In a pure AC capactive circuit:

1 current and voltage are in phase
2 maximum current flows
3 voltage leads the current by 90°
4 current and voltage are 180° out of phase
5 current leads the voltage by 90°

84. In a network with 2 or more sources the current or voltage for any component is the algebraic sum of the effects produced by each source acting separately with all other voltage sources replaced by short circuits and current sources replaced by open circuits is the definition of:

1 Millman's theorem
2 Thevenin's theorem
3 Superposition theorem
4 Norton's theorem
5 current law.

85. A capacitor of 10 uP is charged with a 100k ohm resistor. How long will it take the capacitor in TC's to charge to 5 sec.

1 1 TC
2 2 TC
3 3 TC
4 4 TC
5 5 TC

86. Capacitors oppose any change in:

1 voltage
2 current
3 phase angle
4 capacitive reactance
5 resistance

Section #3 Completion (44 points)

Complete the statement with the correct response. Place the answer in the space provided.

87. The total opposition to current flow in an AC circuit is termed ______________________________.

88-89. A capacitor will reach full charge at 100 volts in the appropriate number of time constants. What is the charge on the capacitor after 3 time constants ______________________________ (2 points)

90. The characteristic of an electronic circuit that tends to oppose any change in current is the definition of ______________________.

91-92. A capacitor has an $X_C$ of 126 ohms with a series resistance of 50 ohms. In this AC series RC circuit, the total circuit resistance is

______________________________ (2 points)

93. A 5, 10, 20, 2 uh inductors are connected in series. The total inductanct is ____________.

94. Materials that do not allow electrons to move freely through them are classified as __________________________.

95. CRT is the abbreviation for ______________________________.

96. Four 100 pf capacitors are in paralle. Their total capactance is

______________.

97-98. The voltage drop across a capacitor is 12.5 volts. With a drop across the resistor of 19.3 volts in a series RC circit, the value of the voltage applied to the circuit is ______________ (2 points).

99. Electrons that flow through all components at the same rate is the definition of a ______________ circuit.

100. A pair of 15 mh inductors are connected in parallel. The total inductance is ______________.

101-102
103. What are the three factors that determine the amount of phase shift in a series RC circuit. (3 points)

1
2
3

104-105. A capacitor takes 1.6875 u sec. to charge to time constants. The value of the charging resistor is 1.5K ohms. The value of the capacitor is ______________________. (2 points)

106. After a certain number of time constants a capacitive RC circuit is considered fully charged. This number of time constants is ________ TC.

107-108. A resistive circuit contains 27 one half watt 12k ohm resistors connected in parallel. The total circuit resistance is ____________. (2 points)

109. A 10 up and a 15 up capacitor are in series. The total capactance is ____________.

110-111
112. Capacitors are used in seven typical applications. One of these are its use in bypassing. List any of the remaining three. (3 points)

1

2

3

Perform the following unit conversions (4 points).

113. 1500 mA = ________________A

114. 230 uV = ________________V

115. 4874 W = ________________kw

116. 4,700,000 ohms = ________________k ohms

117. The capacitive reactance of a 210 pF capacitor at 12 MHz is

______________________________. (2 points)

118. A VOM is marked 20,000 ohms/VDC. When measuring a 37 VDC potential, the meter will put a load of __________ ohms on the circuit.

119-120. A series LR circuit consists of a 23mh coil and a 4.7k ohm resistor. The time it takes for the inductor to reach one TC is ______________ (2 points)

121-122.
123-124. There are eight factors that affect the inductance of a coil. Four of these are: (4 points)

1

2

3

4

125-126. A capacitor exhibits a reactance of 8.501 ohms at 120kHz. The value of the capacitor is __________________________. (2 points)

127. The opposition to current flow in a capacitor is called ___________.

128. The correct scientific notation statement for 2,625,000 is

__________________________.

129. The symbol for conductance is ________________.

130. 6.242 x $10^{18}$ electron charges is the definition of the ___________.

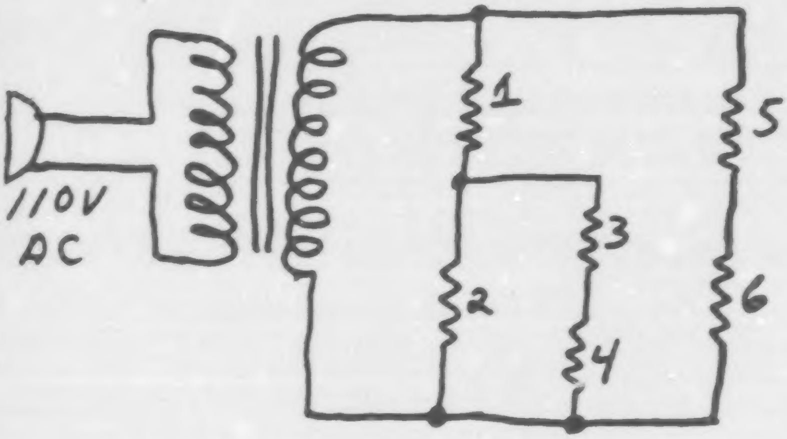
PS 170
Basic Electronics
FINAL PART II

132 points

Name________________________

## SECTION I (15 points)

The provided circuit consists of a step-down transformer connected to a series/parallel resistive circuit. Using the VOM only, measure the RMS voltage drop across resistors #1, #4, and #6.



Resistor #1 __________ (5)

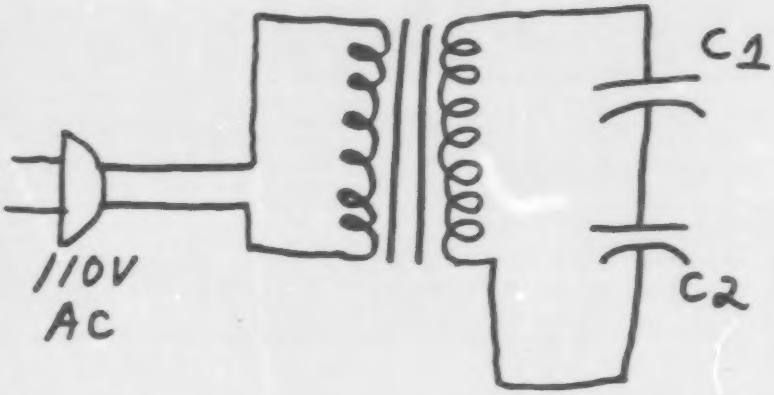
Resistor #4 __________ (5)

Resistor #6 __________ (5)

Name____________________________

SECTION II (10 points)

The provided circuit consists of a step-down transformer connected to a series capacitance circuit. Using the appropriate test instrumentation measure the peak to peak voltage across $C_1$ and $C_2$.



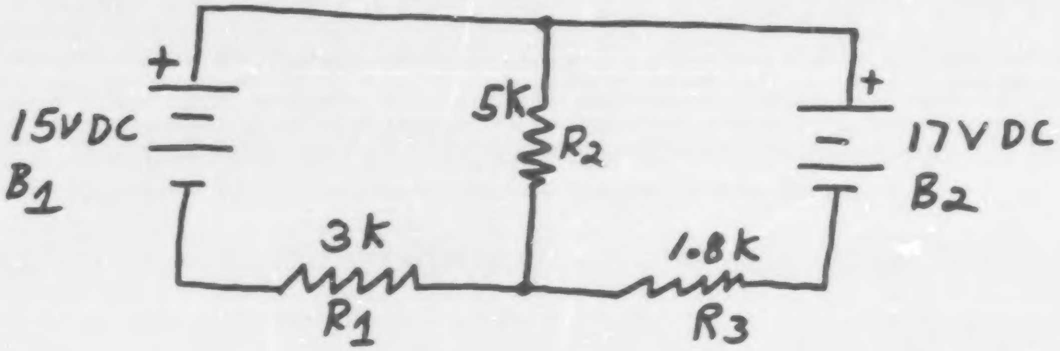
$C_1$ __________(5)

$C_2$ __________(5)

Name ______________________

SECTION III (25 points)

Build the below circuit with parts from the parts cabinet. All resistors must be within + or - 5% of the requested values. Measure the drop across and the current through each component as requested.



+
15VDC
B1
5K
R2
+
17VDC
B2
3k
R1
1.8k
R3

$E_{B_1}$ __________ (2)

$E_{B_2}$ __________ (2)

$E_{R_1}$ __________ (2)

$E_{R_2}$ __________ (2)

$E_{R_3}$ __________ (2)

$I_{B_1}$ __________ (5)

$I_{B_2}$ __________ (5)

$I_{R_3}$ __________ (5)

Name________________________

SECTION IV (13 points)

Using the provided parts, build a series RC circuit and measure the time it takes for the capacitor to charge to one time constant. Select a frequency that will produce optimum results.

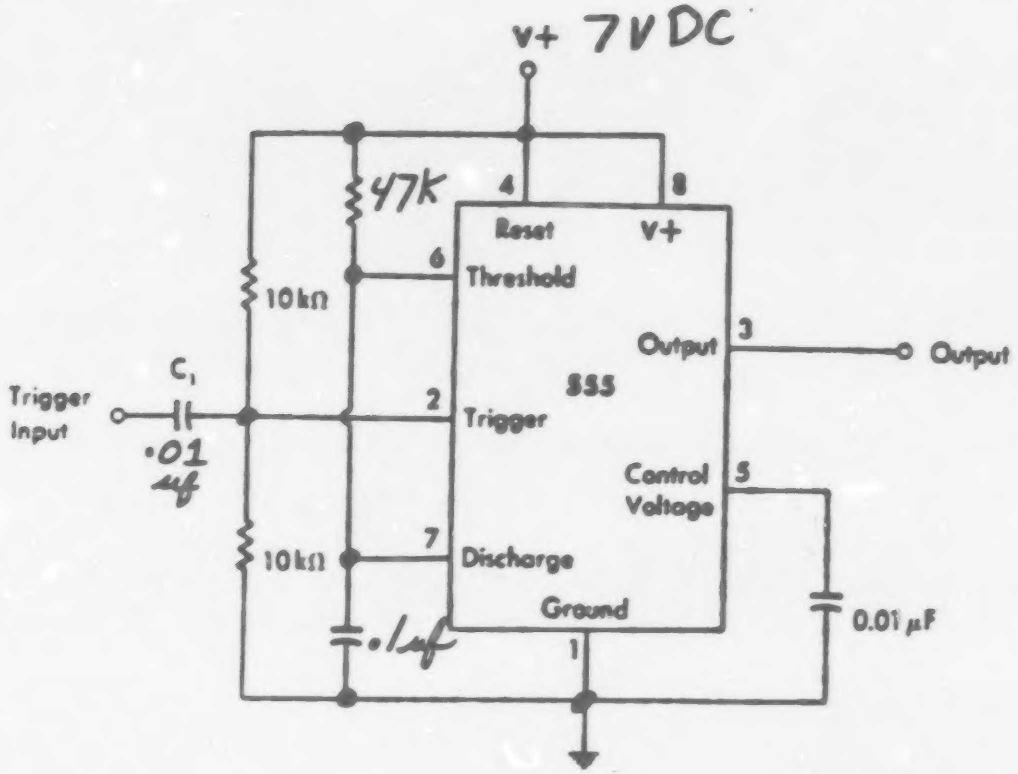
Frequency used __________(3)

1TC ____________________(10)

Name ______________________________

SECTION V (35 points)

Build the below 555 timer circuit using a device obtained from the instructor. Input a TTL square wave at $C_1$ at a frequency of 50Hz. Measure the output waveform's, duty cycle, frequency, and peak output voltage.



V+ 7VDC
47K
4
8
Reset
V+
6
Threshold
10kΩ
Output
3
Output
C₁
Trigger Input
·01 uf
2
Trigger
555
Control Voltage
5
10kΩ
7
Discharge
Ground
·1uf
1
0.01 µF

Output frequency ____________ (10)

Duty cycle __________________ (15)

Peak output voltage __________ (10)

Name ______________________

SECTION VI (34 points)

Build a series RC circuit using the provided parts. Apply a sine wave at a frequency of 400 Hz. Find from the measured data the circuits Z, $\theta$, and $X_c$.

Z ____________ (10)

$\theta$ ____________ (10)

$X_c$ ____________ (10)

$E_c$ ____________ (2)

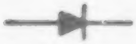
$E_r$ ____________ (2)

## BASIC ELECTRONICS
## PS 170

QUIZ #1
10 POINTS

30 August 1984

NAME________________________

T F 1. The symbol for a diode is 

T F 2. A semiconductor is a material that supports the flow of electrons at all times.

T F 3. An electron is a negatively charged particle which orbits the nucleus of an atom.

T F 4. An insulator restricts the flow of electrons.

T F 5. Silver is an example of an excellent semiconductor.

T F 6. Like charges attract; unlike charges repel.

7. One use of static electricity (electrostatic energy) in industry is

________________________________________________________.

8. The number of electrons in the outer ring of a conductor are/is ____________________.

9. A meter is used to measure the number of coulombs in a circuit. This meter is commonly called a/an ______________ meter.

10. A lamp operated at 10 volts draws 500mA of current. At these ratings the lamp is consuming how many watts of energy? ______________

# BASIC ELECTRONICS

## PS 170

Quiz #2
10 points

Name __________________________

1. A resistor has four bands (L-R) violet, yellow, green and silver. Its value is __________.

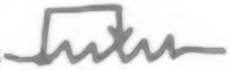
2. The tolerance of the above resistor is dependent on the markings of one of the above bands. The maximum and minimum tolerance for this resistor is a maximum of __________ and a minimum of __________. (2 points)

3. The name of the unit given for conductance is the __________.

4. Divide $8x10^{-16}$ by $2x10^{-12}$. The answer in powers of ten is __________.

5. The square root of $25x10^{8}$ in powers of ten is __________.

6. $6.24x10^{18}$ electrons per second is the definition of a/the ________________.

7. This  is the symbol for a/an __________.

8. A number twelve wire can safely carry twenty amps. The size wire that can safely carry over 20 amps would be ______________________.

9. A resistor in a circuit has 100 volts across it, with a current of ten milliamperes through it. Considering the above, what size of resistor (do not consider a saftey factor) is necessary to properly dissipate the heat generated in this circuit __________ (Answer is not in ohms).

## PS 170
## BASIC ELECTRONICS

Quiz #3
10 points

Name________________________

Information sheets number four and five listed the characteristics of both series and parallel circuits. List five of each of these characteristics in the below area.

Series Circuit Characteristics
1.

2.

3.

4.

5

Parallel Circuit Characteristics
1.

2

3.

4.

5.

PS 170
BASIC ELECTRONICS

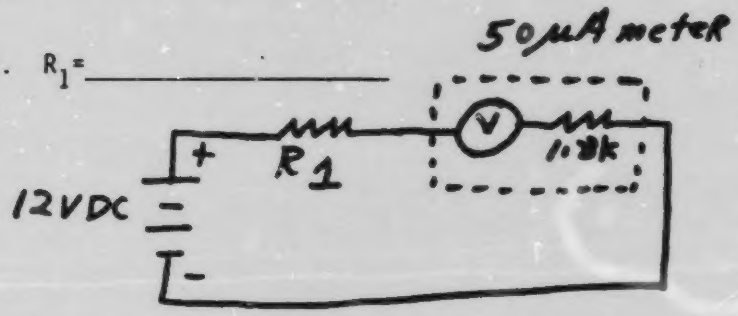
Quiz #4
10 points

Name______________________

Show all math. Answers must be in correct units.

1. $R_1$=________________

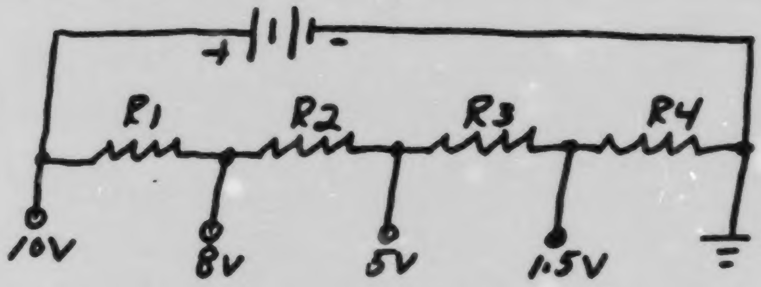
3 pts


50µA meter
+
R1
V
1.8k
12VDC
-

2. $R_1$=________________ $R_2$=________________

$R_3$=________________ $R_4$=________________

4 pts


+
-
R1
R2
R3
R4
10V
8V
5V
1.5V

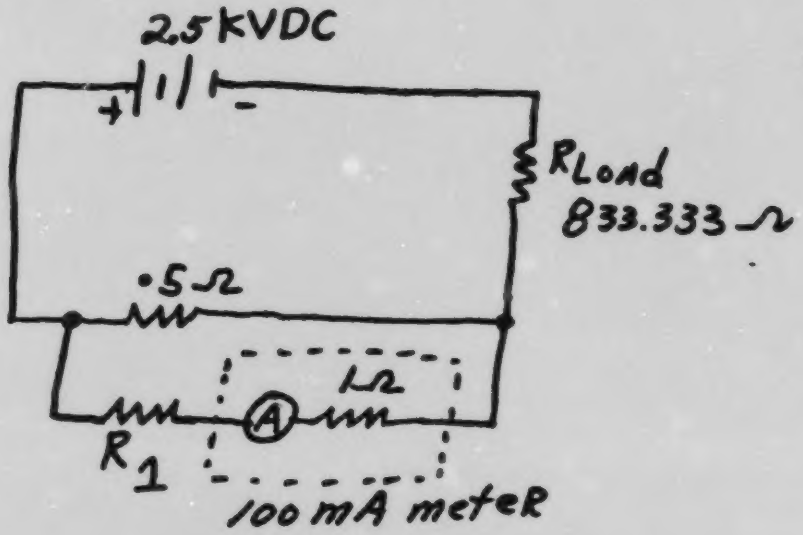
$I_{total}$ = .01 Am

ground is use

AS Reference

3. $R_1$=________________

3 pts


2.5KVDC
+
-
RLoad
833.333 Ω
.5 Ω
1Ω
A
R1
100 mA meter

$I_{MAX}$ = 3 Amps

# PS 170
## Basic Electronics

QUIZ #5
10 Points

Name ______________________________

1. The graticule on front of the CRT is marked off in squares. The size of each square is ________________________________________.

2. When measuring a DC signal the channel select switch must be in the AC position.

   True _________ False _________

3. CRT is the abbreviation for ________________________________________.

4. The mode switch has 4 positions. CHA, CHB, DUAL, and ADD. What is the purpose of the DUAL position?

   ________________________________________________________________

5. The sweep time/cm switch is set at 10 u sec. The signal is 6.35 cm wide. The frequency of the signal is _____________Hz. (2 points)

6. The volts/cm switch is set at 50mV. The signal is 2.5cm High. This signal has a PP voltage of ___________ volts when the probe is in the 10x position. (2 points)

7. The sweep time is calibrated when the outer most control (knob) is in its extreme clockwise position.

   True _________ False _________

8. An external calibrated signal is available to check the scope and probe adjustment. This terminal supplies 75V at 100 mHz for this purpose.

   True _________ False _________

PS 170
Basic Electronics
ALTERNATING CURRENT

Quiz #6
10 points

Name______________________________

1.
2. The amount of induced voltage in a conductor used in a generator is determined by:

1.

2.

3. In Figure 5 the maximum output (voltage) occurs when the conductor is moved in direction ____________.

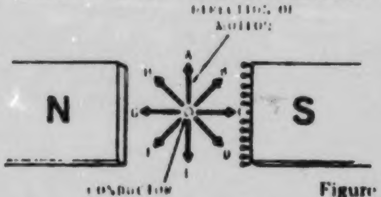
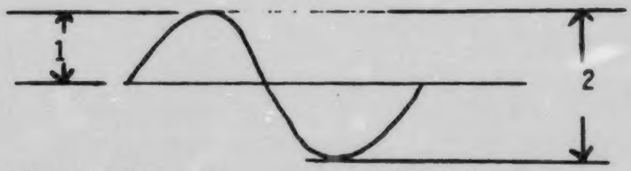


Figure 5

4. What is the instantaneous voltage value of an AC generator that has a peak instantaneous output of 100 volts when the armature angle is ~~270~~ 210 degrees..

5.
6. Lable the AC values
1.______________
2.______________



7. The effective value of 340 volts pp is ________________.

8. Another term to identify $E_{\text{effective}}$ is __________________________.

9 T F The positive half cycle must always occur first in an AC circuit.

10. T F Alternating current must have equal periods of current in each direction in a resistive circuit.

# PS 170
# BASIC ELECTRONICS
# ELECTRICAL UNITS AND CONVERSIONS

## INFORMATION SHEET #1

### ELECTRICAL QUANTITIES

| Electrical Quantity | Letter Symbol | Basic Unit | Abbreviation for Basic Unit |
|---|---|---|---|
| charge | Q | Coulomb | |
| electromotive force | E | volt | V |
| current | I | ampere | A |
| resistance | R | ohm | Ω |
| power | P | watt | W |
| conductance | G | mho | ℧ |
| inductance | L | henry | h |
| capacitance | C | farad | F |
| frequency | f | hertz | Hz |

## UNITS

The basic unit carries the descriptive name for the electrical quantity, such as ampere, ohm, and volt. Multiples are units which are larger than basic units; examples are the kilovolt (one thousand volts), the megawatt (one million watts), and the gigahertz (one billion hertz). Submultiples are units which are smaller than basic units; examples are the milliampere (one thousandth ampere), the microwatt (one millionth watt), the nanosecond (one billionth second), and the picofarad (one trillionth farad). This shows the use of prefixes to create names for multiples and submultiples.

The Table shows the relationship between the seven prefixes that are most common in electronics work.

### PREFIXES COMMONLY USED IN ELECTRONICS

| Prefix | Abbrev. | Power of 10 Numerical Equivalent |
|---|---|---|
| giga | G | $10^9$ |
| mega | M | $10^6$ |
| kilo | k | $10^3$ |
| ... | ... | $10^0$ |
| milli | m | $10^{-3}$ |
| micro | u | $10^{-6}$ |
| nano | n | $10^{-9}$ |
| pico | p | $10^{-12}$ |

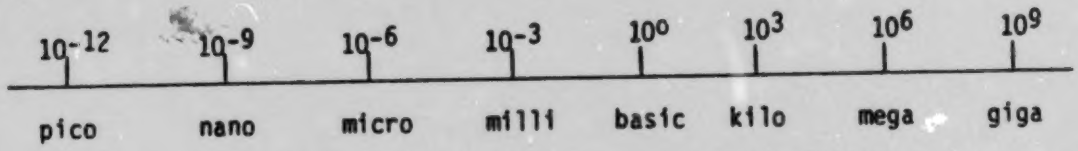
| | ABBREVIATED FORMS | | |
|---|---|---|---|
| Value | Powers of 10 Form | Prefix Form | Fully abbrev. Form |
| 1,000,000,000 hertz | $10^9$ Hz | 1 gigahertz | 1 gHz |
| 1,000,000 ohms | $10^6\ \Omega$ | 1 megohm | 1 M $\Omega$ |
| 1,000 watts | $10^3$ W | 1 kilowatt | 1 kW |
| BASIC UNITS (NO PREFIX) | | | |
| 0.001 ampere | $10^{-3}$ A | 1 milliampere | 1 mA |
| 0.000,001 mho | $10^{-6}\ \mho$ | 1 micromho | 1 umho ($\mu\mho$) |
| 0.000,000,001 second | $10^{-9}$ sec | 1 nanosecond | 1 nsec |
| 1 one-trillionth farad | $10^{-12}$ F | 1 picofarad | 1 pF |

# PS 170
# BASIC ELECTRONICS
# UNIT CONVERSIONS

## INFORMATION SHEET #2

Both the study and application of electronics often require conversion from one size unit to another. One important reason for conversion is that practically all general equations are stated in terms of basic units. We often need to convert from multiples or submiltiples to basic units, so that these basic unit values may be substituted for letter symbols in the general equations. We may then find a numberical solution to the equation.

The below may help us to visualize the unit conversion process. Here we have a prefix scale showing the prefixes commonly used in electronics, and the powers of 10 associated with the prefixes.



A PREFIX SCALE THAT IS USEFUL FOR UNIT CONVERSION

The procedure for using the prefix scale is as follows:

1. When converting to larger units, enter the scale with the prefix given and move to the right. Multiply by $10^3$ at each prefix point. Write the new prefix in the converted form.
2. When converting to smaller units, enter the scale with the prefix given and move to the left. Multiply by $10^{-3}$ at each prefix point. Write the new prefix in the converted form.

EXAMPLE 1: To convert from micro-units to milli-units, enter the scale at micro and move to the right to milli; multiply your value by $10^3$.

Solution: 4 uA - $4 \times 10^{-6} \times 10^{3}$ mA = $4 \times 10^{-3}$ mA

## ET 101
## ELECTRONIC MAINTENANCE

## COMMON SYMBOLS AND ABBREVIATIONS

### INFORMATION SHEET #3

| | |
|---|---|
| ac | alternating current |
| dc | direct current |
| I | amperes, current |
| E | voltage |
| R | resistance |
| W | watts (power) |
| X | reactance |
| L | inductance |
| $K_L$ | inductive reactance |
| C | capacitor |
| $X_c$ | capacitive reactance |
| Z | impedance |
| h | henries (inductance) |
| K | thousand (Kilo-) |
| P | power |
| PD | potential difference |
| emf | electromotive force |
| kwh | kilowatt-hour |
| A.H. | ampere hour |
| Hz | hertz (cycles/second) |
| f | frequency |
| fr | resonant frequency |
| t | time |
| kHz | kilohertz |
| Ω | ohms |
| M | meg-, million |
| u | micro, millionth |
| ua | microampere |
| uf | microfarad |
| uh | microhenry |
| uv | microvolt |
| m | milli |
| Ma | milliampere |
| MHz | megahertz |
| mv | millivolt |
| mw | milliwatt |
| mh | millihenry |
| RF | radio frequency |
| AM | amplitude modulated |
| FM | frequency modulated |

INFORMATION SHEET #4 PS 170

## SERIES CIRCUIT

In a series circuit the current is the same at all points in the circuit.

The total resistance of a series circuit equals the sum of the individual resistance values.

The sum of all voltages in a closed loop series circuit equals the applied voltage.

If a series circuit contains only one resistor, that resistors drop equals the applied voltage.

When a series circuit contains two or more resistors, the larger value resistor (in ohms) drops the most voltage.

Current in a series circuit is directly proportional to the total voltage, and is inversely proportional to resistance.

Total voltage in a series circuit is equal to the product of the current times the total resistance.

The voltage drop across a resistor in a series circuit is directly proportional to the resistor's ohmic value.

Total power consumed by a circuit equals the sum of all the individual power dissipations.

# INFORMATION SHEET #5
# PARALLEL CIRCUITS

A parallel circuit contains two or more paths for current flow.

Resistors connected in parallel across a voltage source will have that total voltage applied.

In a parallel circuit, the total resistance is less than the resistance in the smallest branch.

When a branch is removed from a parallel circuit, total resistance and total current decreases.

Adding a branch to a parallel circuit causes total resistance to decrease and total current to increase.

When one branch of a parallel circuit opens, the remaining branches continue to operate normally.

Each branch of a parallel circuit is part of a separate closed loop.

The voltage drop on each branch of a parallel circuit equals the voltage applied to that portion of the circuit.

Total current in a parallel circuit equals the sum of the individual branch currents.

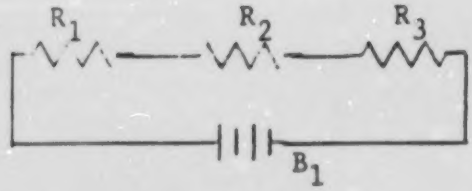
The total power of a parallel circuit equals the sum of all the individual dissipations.

The branch with the greatest resistance has the least current flow and dissipates the least power.

PS 170
BASIC ELECTRONICS

Information Sheet #6
Math Test Samples

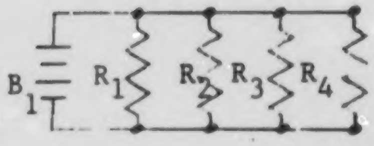
1



KNOWN
$B_1$, $R_1$ through $R_3$

FIND
$R_t$, $I_t$

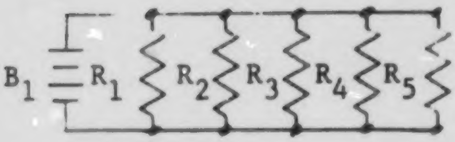
2


$B_1$
$R_1$
$R_2$
$R_3$
$R_4$

KNOWN
$B_1$, $R_1$ through $R_4$

FIND
$R_t$

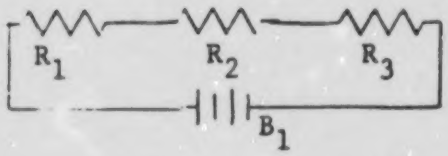
3


$B_1$
$R_1$
$R_2$
$R_3$
$R_4$
$R_5$

KNOWN
$B_1$, $R_1$ through $R_5$, $P_{R_1}$ thourgh $P_{R_5}$

FIND
$R_t$, $P_t$

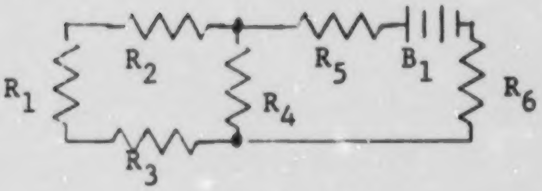
4



KNOWN
$B_1$, $R_1$ through $R_3$, $I_t$

FIND
R of connecting wire

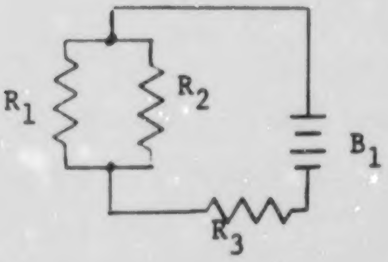
5


$R_2$
$R_5$
$B_1$
$R_1$
$R_4$
$R_6$
$R_3$

KNOWN
$B_1$, $R_1$ through $R_6$

FIND
$R_t$

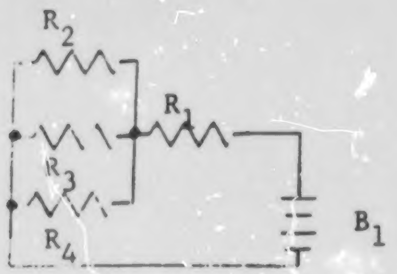
6



KNOWN
$R_1$, $R_3$, $P_{R_1}$, $P_{R_3}$

FIND
$I_t$, $B_1$, $R_2$, $R_t$

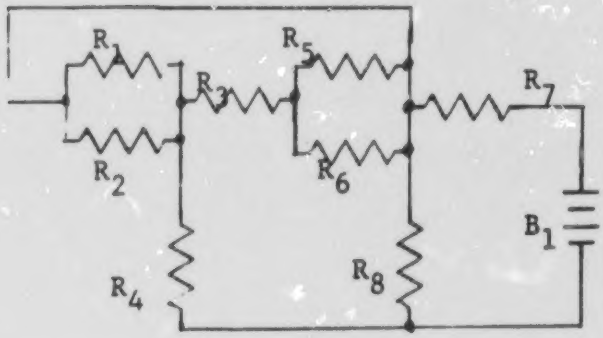
7


$R_2$
$R_1$
$R_3$
$R_4$
$B_1$

KNOWN
$B_1$, $R_1$ through $R_4$

FIND
$R_t$, $I_t$, $I_{R_4}$, $E_{R_1}$

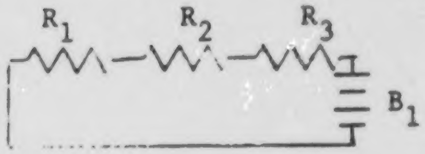
8


$R_1$
$R_5$
$R_3$
$R_7$
$R_2$
$R_6$
$B_1$
$R_4$
$R_8$

KNOWN
$R_1$ through $R_8$

FIND
$R_t$

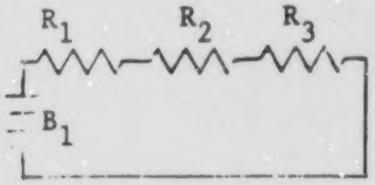
9



KNOWN
$B_1$, $R_1$ through $R_3$

FIND
$I_t$, $E_{R_2}$, $P_{R_1}$

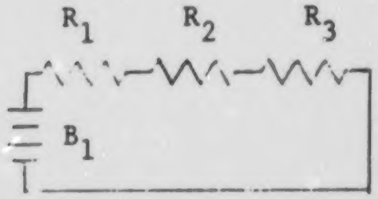
10



KNOWN
$E_{R_2}$, $R_1$ through $R_3$

FIND
$I_t$, $E_{B_1}$

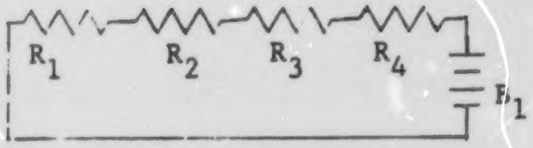
11



KNOWN
$E_{R_1}$, $E_{R_2}$, $R_3$, $B_1$

FIND
$I_t$, $R_1$, $R_t$

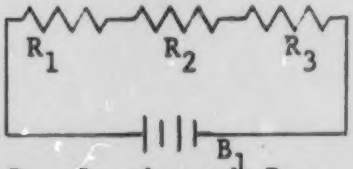
12


$R_1$
$R_2$
$R_3$
$R_4$
$B_1$

KNOWN $E_{R_2}$, $R_1$ through $R_4$

FIND $I_t$, $E_{B_1}$, $P_{R_4}$

13



KNOWN $B_1$, $R_1$ through $R_3$

FIND $R_t$

PS 170

BASIC ELECTRONICS

RC CIRCUIT FORMULAS

## INFORMATION SHEET #7

These formulas show how impedance, reactance, resistance and phase shift in a series RC circuit are related mathematically.

$$\sin\theta = \frac{X_c}{Z}$$

$$\cos\theta = \frac{R}{Z}$$

$$\tan\theta = \frac{X_c}{R}$$

$$R = Z\cos\theta$$

$$R = \frac{X_c}{\tan\theta}$$

$$X_c = Z\sin\theta$$

$$X_c = R\tan\theta$$

$$Z = \frac{X_c}{\sin\theta}$$

$$Z = \frac{R}{\cos\theta}$$

$$\theta = \arcsin\frac{X_c}{Z}$$

$$\theta = \arccos\frac{R}{Z}$$

$$\theta = \arctan\frac{X_c}{R}$$

# PS 170
# BASIC ELECTRONICS
# FINAL STUDY GUIDE
# PART I

## INFORMATION SHEET #8

- Convert to scientific notation
- Conductance symbol
- Wire resistance properties
- DMM ohmmeter use
- Parallel resistance problem
- Resonance
- Electron
- VOM ohmmeter use
- Insulator
- Coulombs
- Cathode ray tube
- Graticule
- Series resistive circuit characteristics
- Power in parallel and series circuits
- Duty cycle
- Capacitor useages
- Time constants
- Parallel resistive circuit characteristics
- Slew rate
- Law of conservation of charge
- Node
- Kirchoff's voltage law
- Ohms per volt
- Pulse rise time
- Perform unit conversions
- Conductance of materials
- Resistivity
- Resistor dissapations
- Pulse Train
- Linear pot
- Voltage law
- Electromagnetic Induction
- Capacitive reactance
- RC circuit characteristics
- Potentiometer
- Norton's theorem
- Generator characteristics
- Series and parallel capacitance
- Alternating current
- Magnetic field and wire movement
- Superposition theorem
- Sine function
- Cycle
- Rheostat
- Current law
- Thevenin's theorem
- Peak AC value
- Circuit phase relationship's
- Parallel and series AC resistive circuits
- Resistive AC power
- Effective AC value
- Peak to peak AC value
- Sine wave
- Characteristics of inductor and capacitors
- Henery
- Coil inductance factors
- Capactive and inductive phase relationships
- Impedance caculations
- Wire cross-sectional area
- Farad
- Inductive reactance
- Phase angle calculations
- Ohm
- Self inductance
- Inductance
- Counter EMF
- Series RC phase shift factors
- Parallel and series inductance

## WRITTEN TEST COMPOSITION

True and False - - - - - 56
Multiple Choice - - - - 30
Short Answer Fill-in - - 44

# PS 170
# BASIC ELECTRONICS
## Unit Conversions

Assignment #1
20 Points

Name____________________

1. Convert 250ma to amperes__________
2. Convert 1,500 watts to kilowatts__________
3. Convert 200,000Ω to megohms__________
4. Convert 2.3 kΩ to ohms__________
5. Convert 2.2 MΩ to ohms__________
6. Convert .05 amp to ma__________
7. Convert 10,000 volts to kilovolts__________
8. Convert 47,000Ω to kΩ__________
9. Convert 1.2 MΩ to ohms__________
10. Convert 200μa to ma__________
11. Convert 65 volts to mv__________
12. Convert 5.25 amp to ma__________
13. Convert 0.45 volt to mv__________
14. Convert 75 ma to μa__________
15. Convert 50 kΩ to ohms__________
16. Convert 0.045 amp to μa__________
17. Convert 6.6 kv to volts__________
18. Convert 0.25 kw to watts__________
19. Convert 6,750μa to amps__________
20. Convert 0.01 kv to volts__________

PS 170
BASIC ELECTRONICS
Color Code

Assignment #2
80 points

Name____________________________

Values of resistors are specified by a recognized color code. The values of the resistors are specified by listing the various bands from left to right. (Red Green Orange Silver is a 25,000Ω or 25kΩ resistor.) Using the indicated bands, determine the resistors value in the specified units and the resistors tolerance in percentage. (One point for each correct value and tolerance.)

| | | | | | Value | Tolerance |
|---|---|---|---|---|---|---|
| 1. | Orange | Orange | Red | Gold | 3.3 k | 5% |
| 2. | Brown | Green | Yellow | | ____k | ____ |
| 3. | Green | Blue | Green | Silver | ____M | ____ |
| 4. | Blue | Gray | Brown | Silver | ____Ω | ____ |
| 5. | Yellow | Violet | Orange | | ____k | ____ |
| 6. | Brown | Green | Green | | ____M | ____ |
| 7. | Red | Violet | Orange | Gold | ____k | ____ |
| 8. | Gray | Red | Yellow | Gold | ____k | ____ |
| 9. | Red | Red | Red | Silver | ____k | ____ |
| 10. | Gray | Red | Black | Gold | ____Ω | ____ |
| 11. | Orange | Orange | Green | | ____M | ____ |
| 12. | Brown | Red | Brown | Gold | ____Ω | ____ |
| 13. | Blue | Gray | Yellow | Gold | ____k | ____ |
| 14. | Brown | Black | Green | Gold | ____M | ____ |
| 15. | Orange | White | Red | | ____k | ____ |
| 16. | Red | Red | Orange | | ____k | ____ |
| 17. | Orange | Orange | Orange | | ____k | ____ |
| 18. | Yellow | Violet | Black | | ____Ω | ____ |
| 19. | Red | Violet | Gold | Gold | ____Ω | ____ |
| 20. | Brown | Black | Blue | Silver | ____M | ____ |

In the preceding examples the k, M, and Ω symbols were used to indicate the values in an industrial accepted form. In the following, indicate the value along with the proper units of k, M, or Ω. (One point each for correct value and symbol.)

| | | | | Value | Units |
|---|---|---|---|---|---|
| 21. | Orange | Black | Green | 3 | M |
| 22. | Yellow | Violet | Red | | |
| 23. | Yellow | Violet | Green | | |
| 24. | Gray | Red | Red | | |
| 25. | Orange | Orange | Gold | | |
| 26. | Brown | Red | Orange | | |
| 27. | Green | Blue | Yellow | | |
| 28. | Red | Red | Brwon | | |
| 29. | Brown | Black | Orange | | |
| 30. | Blue | Gray | Green | | |
| 31. | Orange | Orange | Black | | |
| 32. | Red | Red | Yellow | | |
| 33. | Blue | Gray | Red | | |
| 34. | Brown | Black | Red | 1 | k |
| 35. | Green | Blue | Red | | |
| 36. | Brown | Red | Green | | |
| 37. | Red | Violet | Black | | |
| 38. | Brown | Black | Yellow | | |
| 39. | Orange | White | Green | | |
| 40. | Brown | Gray | Gold | | |

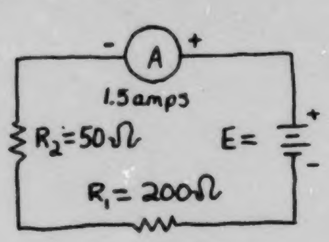
PS 170
BASIC ELECTRONICS
Series Circuit Problems

Assignment #3
20 Points

Name________________________

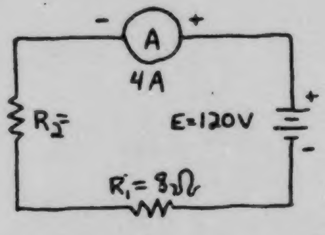
Complete this assignment providing the requested information. Show all mathematical calculations used in arriving at your answer. If sufficient space is not available additional sheets may be attached. Responses without work will be considered wrong. Place answers in provided blanks.

1. E total=____________



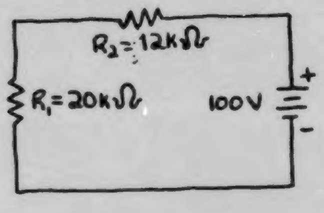
- A +
1.5amps
$R_2$=50Ω
E=
+
-
$R_1$= 200Ω

2. $R_2$=______________



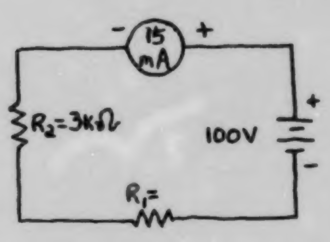
- A +
4A
$R_2$=
E=120V
+
-
$R_1$= 8Ω

3. I total=____________



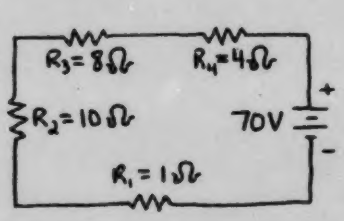
$R_2$=12KΩ
$R_1$=20KΩ
100V
+
-

4. $R_1$=______________



- 15 mA +
$R_2$=3KΩ
100V
+
-
$R_1$=

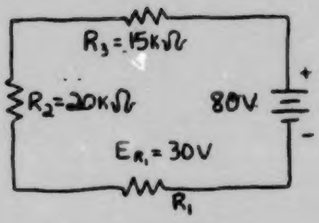
5. I total=____________



$R_3$= 8Ω
$R_4$=4Ω
$R_2$=10Ω
70V
+
-
$R_1$= 1Ω

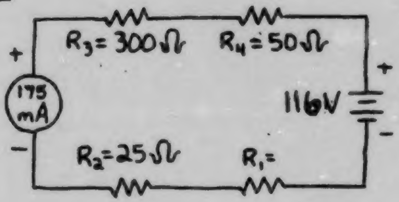
Assignment #3 Cont.

6. $R_1$=________________



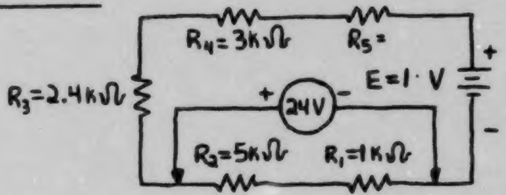
R₃=15KΩ
R₂=20KΩ
80V
+
-
E_R₁=30V
R₁

7. $R_1$=________________



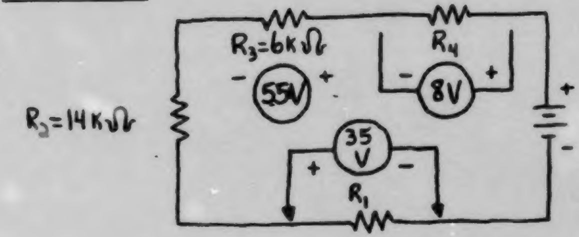
R₃=300Ω
R₄=50Ω
+
175 mA
-
116V
+
-
R₂=25Ω
R₁=

8. $R_5$=________________



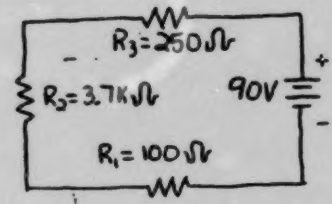
R₄=3KΩ
R₅=
E=1 V
+
-
R₃=2.4KΩ
+
24V
-
R₂=5KΩ
R₁=1KΩ

9. R total=__________



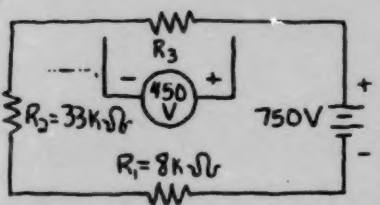
R₃=6KΩ
R₄
-
55V
+
-
8V
+
R₂=14KΩ
35 V
+
-
R₁
+
-

10. I total=________________



R₃=250Ω
R₂=3.7KΩ
90V
+
-
R₁=100Ω

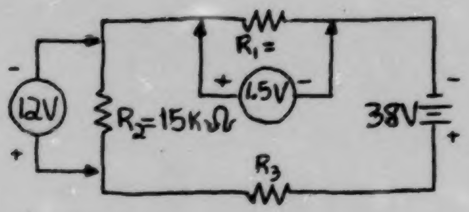
11. I total=________________



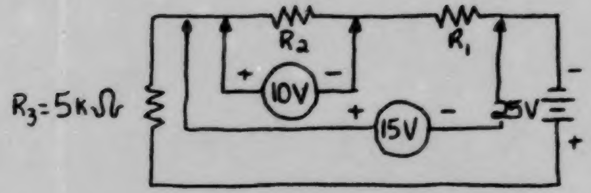
R₃
-
450 V
+
R₂=33KΩ
750V
+
-
R₁=8KΩ

Assignment #3 Cont.

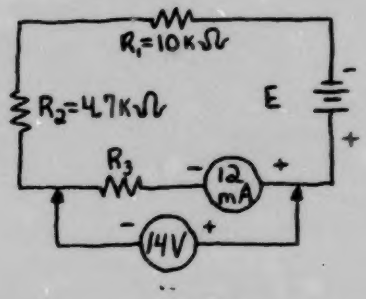
12. $R_1$= ____________________


12V
R₁=
1.5V
R₂=15KΩ
38V
R₃
+
-

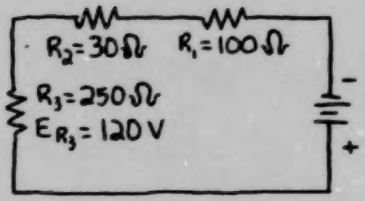
13. I total= ____________________


R₂
R₁
R₃=5KΩ
10V
15V
25V
+
-

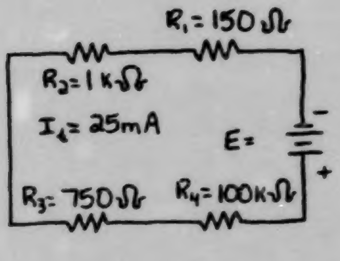
14. E total= ____________________


R₁=10KΩ
R₂=4.7KΩ
E
R₃
12 mA
14V
+
-

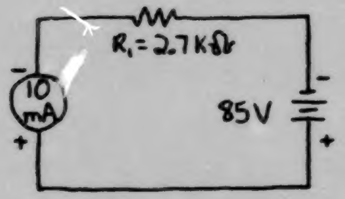
15. E total= ____________________


R₂=30Ω
R₁=100Ω
R₃=250Ω
E_R₃=120V
+
-

16. E total= ____________________

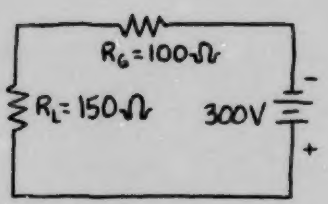

R₁=150Ω
R₂=1KΩ
I₄=25mA
E=
R₃=750Ω
R₄=100KΩ
+
-

17. $P_{R_1}$= ____________________

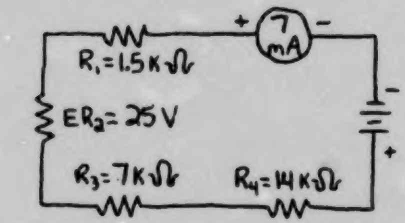

R₁=2.7KΩ
10 mA
85V
+
-

Assignment #3 Cont.

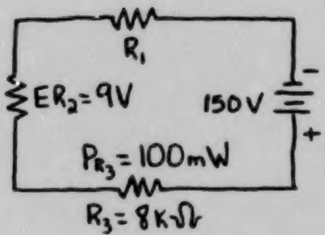
18. $P_{R_L}$ = ____________________


R_G = 100Ω
R_L = 150Ω
300V
-
+

19. $P_{R_1}$ = ____________________


+
7 mA
-
R₁ = 1.5KΩ
ER₂ = 25V
R₃ = 7KΩ
R₄ = 14KΩ
-
+

20. $P_{R_1}$ = ____________________


R₁
ER₂ = 9V
150V
-
+
P_R₃ = 100mW
R₃ = 8KΩ

# PS 170
# BASIC ELECTRONICS
# WATT-SERIES PROBLEMS

ASSIGNMENT #4
33 points

Name ______________________________

The below problems will make use of the following equations:

$$E = I \times R$$

$$I = \frac{E}{R}$$

$$R = \frac{E}{I}$$

$$P = I \times E$$

$$P - I^2R$$

$$P = \frac{E^2}{R}$$

Place the requested response in the provided blanks. Show all work. Responses without mathematical work will not receive credit. Additional sheets may be attached if desired.

1. A voltage of 110V across a resistor causes a current of 6 amps to flow through it. (2 points)
   Power = ____________

   R = ___________

2. A current of 2.5 amp flow through a resistance of 50 ohms. (2 points)
   Power = ___________

   Voltage across resistor = _____________

3. A voltage of 2.916 volts is applied across a 750 ohm resistor. (2 points)
   Power = ___________

   I = _____________

4. What is the hot resistance of a 60 watt 120 volt lamp? (2 points)
   R = _____________

   I = _____________

5. A motor delivering 10.75 horsepower is drawing 65.5 amp from a 240 volt line. (1 point)
   P = _____________

6. A soldering iron draws .45 amp from a 120 volt line. (2 points)
P = ____________

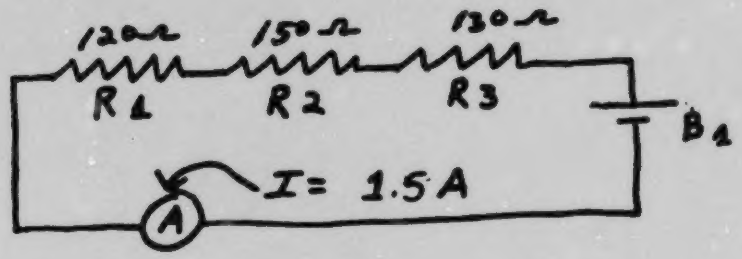
R = ____________

7. A voltmeter connected across a 150 ohm resistor reads 175 volts. (1 point)
P = ____________

8. A wattmeter is connected in a 440 volt line ahead of a motor. When the motor is running the wattmeter reads 2.5kw. (1 point)
I = ____________

9. Determine the power expended in an ammeter with an internal resistance of .017 ohm when the meter reads 8 amps. (1 point)

10.



Voltage across $R_1$ = ____________

Voltage across $R_3$ = ____________

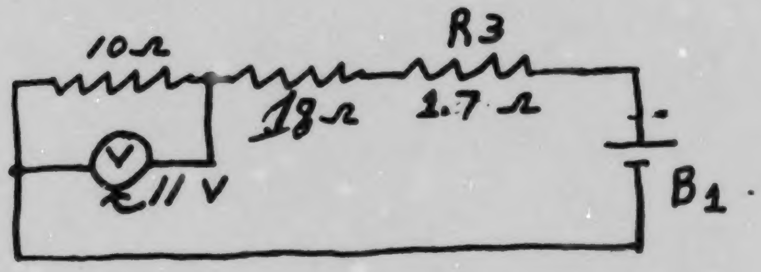
$B_1$ voltage = ____________

Power dissipated by $R_1$ = ____________

Power dissipated by $R_2$ = ____________

Total power = ____________

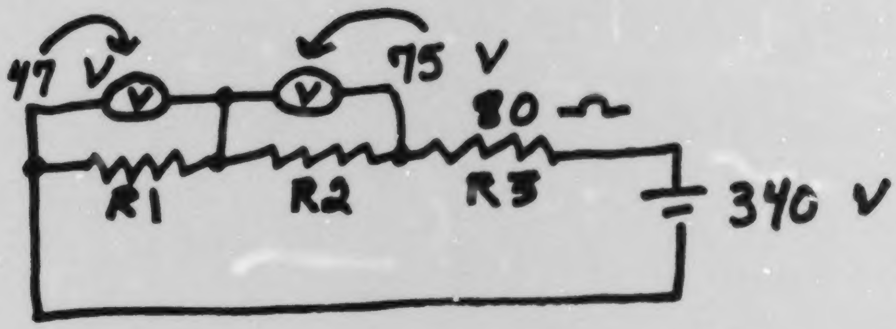
11.



Power dissipated by $R_3$ = ____________

$B_1$ voltage = ____________ (2 points)

12.


47 V
75 V
80 Ω
R1
R2
R3
340 V

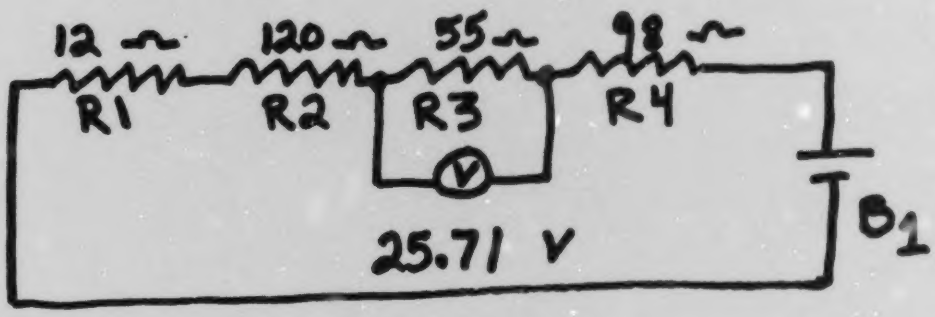
$R_1$ = ______________

$R_2$ = ______________

$I_{total}$ = ___________ (5 points)

Power dissipated by $R_1$ = ______________

Total power = ____________


12 Ω
120 Ω
55 Ω
98 Ω
R1
R2
R3
R4
25.71 V
B1

$B_1$ = ______________

$I_{total}$ = ___________ (4 points)

Total power = __________

Voltage across $R_4$ = ___________

14. Three resistors of 2.7, 8.9 and 14.2 ohms are connected in series across a 13.8 volt battery with a resultant current of 410 mA. Determine the resistance of the connecting wires.
Wire resistance = ____________

15. A 8,000 ohm 50 watt resistor, a 16,000 ohm 110 watt resistor, and a 25,000 —⌒—, 15 watt resistor are connected in parallel. Determine the maximum permissible value of current through this parallel combination that will not exceed the rating of any resistor. (1 point)
I = ________________

## ANSWER SHEET

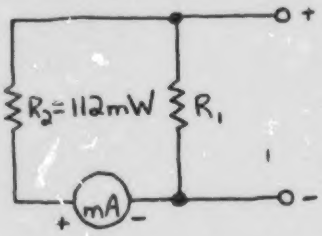
1. Power = ______________
R = __________________
2. Power = ______________
Voltage across resistor = ______________
3. Power = ______________
I = __________________
4. R = __________________
I = __________________
5. P = __________________
6. P = __________________
R = __________________
7. P = __________________
8. I = __________________
9. P = __________________
10. Voltage across $R_1$ = __________
Voltage across $R_3$ = __________
$B_1$ voltage = ________
Power dissipated by $R_1$ = ______
Power dissipated by $R_2$ = ______
Total Power = _______
11. Power dissipated by $R_3$ = ______
$B_1$ voltage = ________
12. $R_1$ = ________
$R_2$ = ________
$I_{total}$ = ________
Power dissipated by $R_1$ = ________
Total power = _________
13. $B_1$ = __________
$I_{total}$ = ______
Total Power = ________
Voltage across $R_4$ = ______
14. Wire resistance = _______
15. I = _________

# PS 170
# BASIC ELECTRONICS
## Parallel Circuit Problems

Assignment #5
10 Points

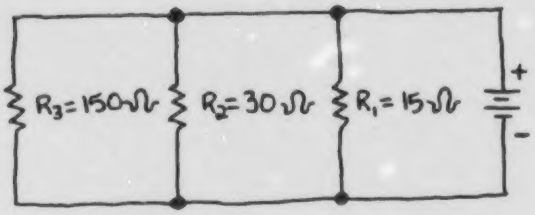
Name ______________________

Complete this assignment providing the requested information. Show all mathematical calculations used in arriving at your answer. If sufficient space is not available additional sheets may be attached. Responses without work will be considered wrong. Place answers in the provided blanks.



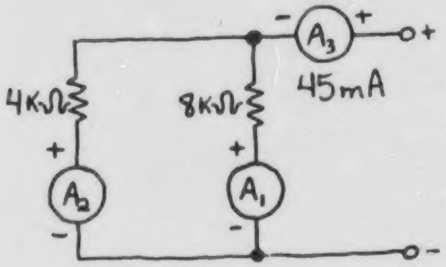
+
$R_2$=112mW
$R_1$
mA
+
-
-

1. E applied= ____________________



$R_3$=150Ω
$R_2$=30Ω
$R_1$=15Ω
+
-

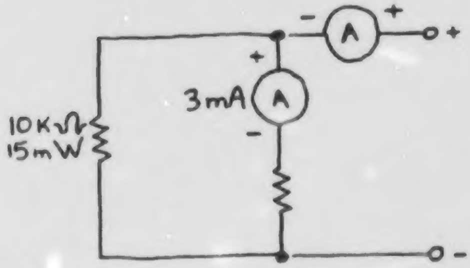
2. R total= ____________________



-
$A_3$
+
+
45mA
4KΩ
8KΩ
+
+
$A_2$
$A_1$
-
-
-

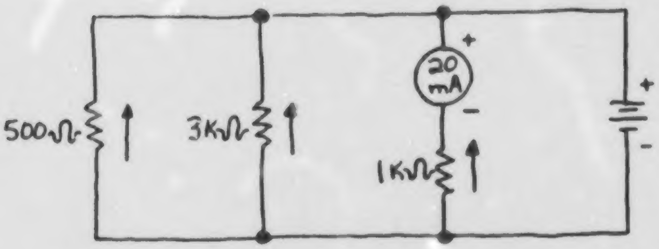
3. $I_{A_1}$= ____________________

$I_{A_2}$= ____________________



-
A
+
+
+
3mA
A
-
10KΩ
15mW
-

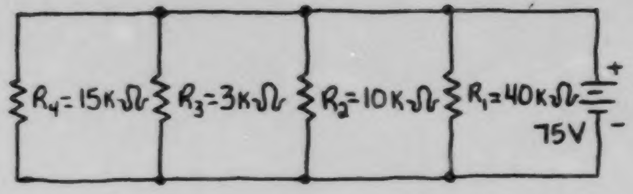
4. I total= ____________________



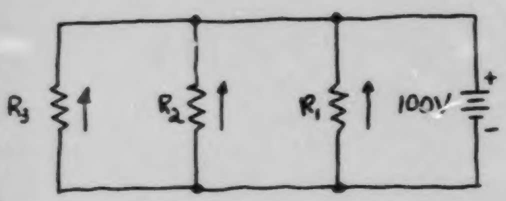
+
20 mA
-
+
-
500Ω
3KΩ
1KΩ

5. I total= ____________________

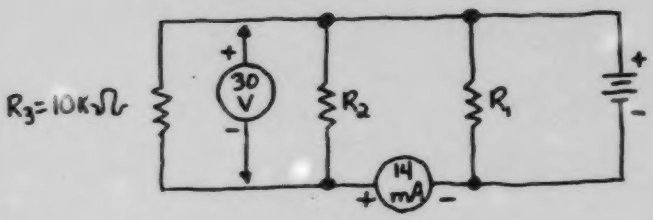
Assignment #5 Cont.


R4=15KΩ
R3=3KΩ
R2=10KΩ
R1=40KΩ
+
75V
-

6. $P_{R_1}$= ____________________


R3
R2
R1
100V
+
-

7. $E_{R_1}$= ____________________ when $R_3$ is shorted

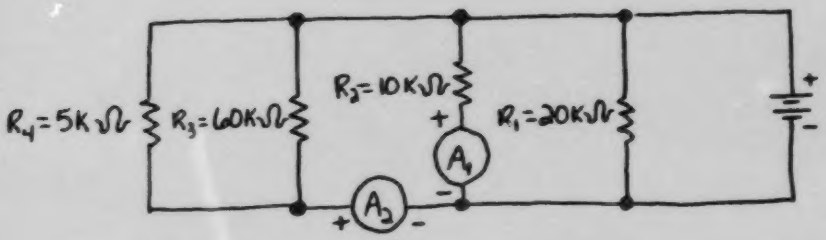

R3=10KΩ
+
30 V
-
R2
R1
+
-
14 mA
+
-

8. $R_2$= ____________________

9. $I_{A_2}$= ____________________

when $R_4$ opens

$A_1$ reads 4mA

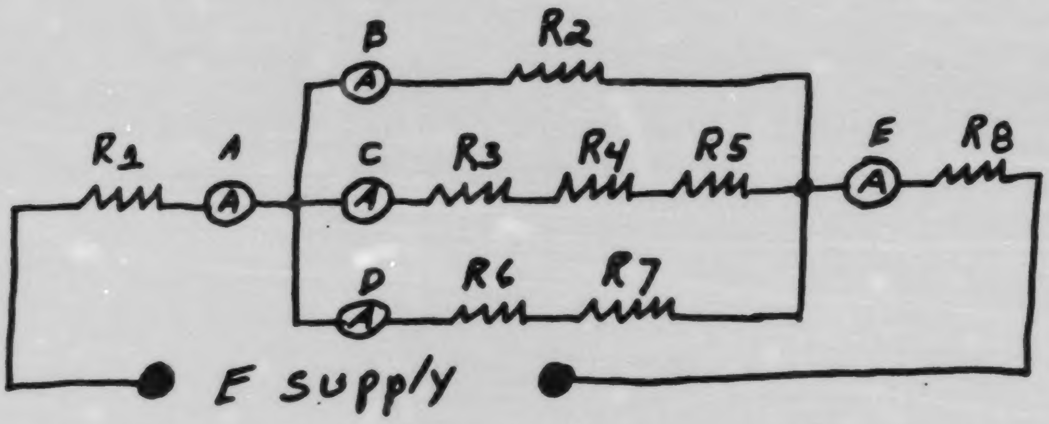

R4=5KΩ
R3=60KΩ
R2=10KΩ
+
A1
-
R1=20KΩ
+
A2
-
+
-

# PS 170
# Basic Electronics
# Calculations

Assignments #6
115 points

Name ____________________

This assignment requires the selection of resistance values for a circuit in which portions will be opened or shorted. The resistance values will be selected from those listed in chart #1. The circuit parameters are as follows: voltage applied to the circuit may range from 5 to 15 volts DC. The power dissipated under the worst case may not exceed 1/4 watt per resistor. (Note: Resistors are 1/4 watt in size.) The current through the circuit shall be some selected value that allows for ease of reading on the VOM. Meter scales are 1mA, 10mA, 100mA and 500mA. Note: Once E supply is chosen, it must remain the same for all examples. The circuit diagram is as follows:



Circuit #1

Chart #1

| Ohms | Ohms | Ohms | Ohms | Ohms |
|---|---|---|---|---|
| 10 | 75 | 330 | 2.7K | 18K |
| 22 | 100 | 390 | 3.3K | 22K |
| 33 | 150 | 470 | 3.9K | 27K |
|  | 220 | 560 | 4.7K | 33K |
|  | 270 | 680 | 5.6K | 39K |
|  |  | 820 | 6.8K | 47K |
|  |  | 1K | 8.2K | 56K |
|  |  | 1.5K | 9.1K | 68K |
|  |  | 1.8K | 10K | 82K |
|  |  | 2.2K | 12K | 100K |
|  |  |  | 15K |  |

The below requested information is not given in the order necessary for circuit value calculation. It is suggested that the starting point be for the worst possible case example.

Calculate the below values for circuit 1. This circuit operates in a normal fashion.

$R_1$ ________

$R_2$ ________

$R_3$ ________

$R_4$ ________

$R_5$ ________

$R_6$ ________

$R_7$ ________

$R_8$ ________

*R total ________

$I_A$ ________

$I_B$ ________

IC ________

$I_D$ ________

$I_E$ ________

E supply ________

$E_{R_1}$ ________

$E_{R_2}$ ________

$E_{R_3}$ ________

$E_{R_4}$ ________

$E_{R_5}$ ________

$E_{R_6}$ ________

ER7 ________

$E_{R_8}$ ________

$P_{R_1}$ ________

$P_{R_2}$ ________

$P_{R_3}$ ________

$P_{R_4}$ ________

$P_{R_5}$ ________

$P_{R_6}$ ________

$P_{R_7}$ ________

$P_{R_8}$ ________

P total ________

* equivalent total circuit resistance

Calculate the below requested values for circuit #1 with $R_2$ removed from the circuit without altering E supply.

*R total ________

E supply ________

$E_{R_1}$ ________

$E_{R_2}$ ________

$E_{R_3}$ ________

$E_{R_4}$ ________

$E_{R_5}$ ________

$E_{R_6}$ ________

$E_{R_7}$ ________

$E_{R_8}$ ________

$I_A$ ________

$I_B$ ________

$I_C$ ________

$I_D$ ________

IE ________

$P_{R_1}$ ________

$P_{R_2}$ ________

$P_{R_3}$ ________

$P_{R_4}$ ________

$P_{R_5}$ ________

$P_{R_6}$ ________

$P_{R_7}$ ________

$P_{R_8}$ ________

P total ________

Calculate the below requested values for circuit #1 with $R_2$ shorted without altering E supply.

*R total __________

E supply __________

$E_{R1}$ __________

$E_{R2}$ __________

$E_{R3}$ __________

$E_{R4}$ __________

$E_{R5}$ __________

$E_{R6}$ __________

$E_{R7}$ __________

$E_{R8}$ __________

$I_A$ __________

$I_B$ __________

$I_C$ __________

$I_D$ __________

$I_E$ __________

$P_{R1}$ __________

$P_{R2}$ __________

$P_{R3}$ __________

$P_{R4}$ __________

$P_{R5}$ __________

$P_{R6}$ __________

$P_{R7}$ __________

$P_{R8}$ __________

P total __________

Calculate the below requested values for circuit #1 with $R_8$ removed from the circuit without altering E supply.

*R total __________

E supply __________

$E_{R_1}$ __________

$E_{R_2}$ __________

$E_{R_3}$ __________

$E_{R_4}$ __________

$E_{R_5}$ __________

$E_{R_6}$ __________

$E_{R_7}$ __________

$E_{R_8}$ __________

$I_A$ __________

$I_B$ __________

$I_C$ __________

$I_D$ __________

$I_E$ __________

$P_{R_1}$ __________

$P_{R_2}$ __________

$P_{R_3}$ __________

$P_{R_4}$ __________

$P_{R_5}$ __________

$P_{R_6}$ __________

$P_{R_7}$ __________

$P_{R_8}$ __________

P total __________

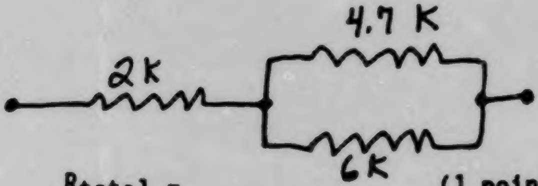
PS 170
BASIC ELECTRONICS
SERIES PARALLEL CIRCUIT

Assignment #7
20 points

Name ________________

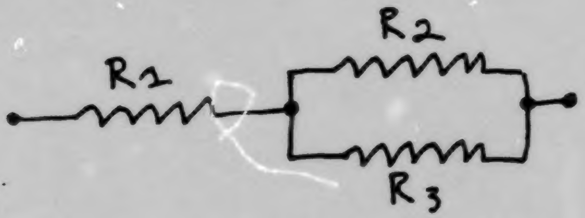
Complete this assignment providing the requested information. Show all mathematical calculations used in arriving at your answer. If sufficient space is not available, additional sheets may be attached. Responses without work will be considered wrong. Place answers in provided blanks.

1.



Rtotal = ______________ (1 point)

2. In this circuit $R_1$ = 4.7k $R_2$ - 2.2k, Itotal - 58.6 MA and the voltage across $R_3$ is 74.4 volts.



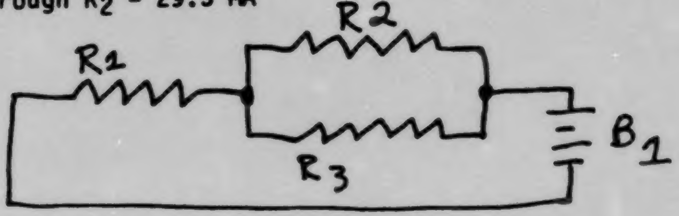
$R_3$ = ______________

(4 points)

Current through $R_2$ = ____________

Current through $R_3$ = ____________

3. In this circuit $R_1$ = 5.6k, Rtotal = 7.18k, $B_1$ = 1000 volts, current through $R_2$ = 29.3 MA



Voltage across $R_1$ = __________

Voltage across $R_2$ = ________

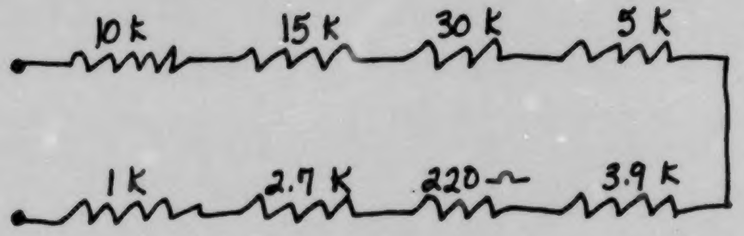
Resistance of $R_2$ = __________

Resistance of $R_3$ = ________

Total current = ____________
(6 points)

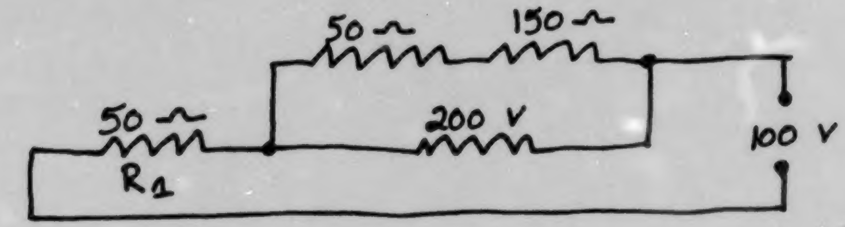
Current through $R_3$ = _______

4.


10 k
15 K
30 K
5 K
1 K
2.7 K
220 Ω
3.9 K

$R_{total}$ = __________ (1 point)

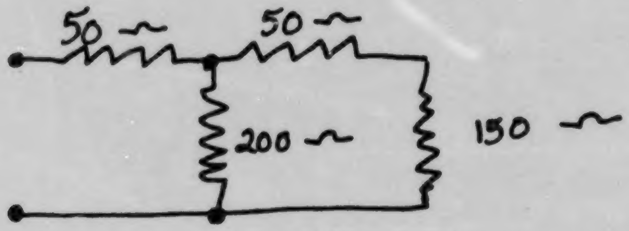
5.


50 Ω
150 Ω
50 Ω
200 V
100 V
$R_1$

$R_{total}$ = __________ Voltage across $R_1$ __________ (2 points)

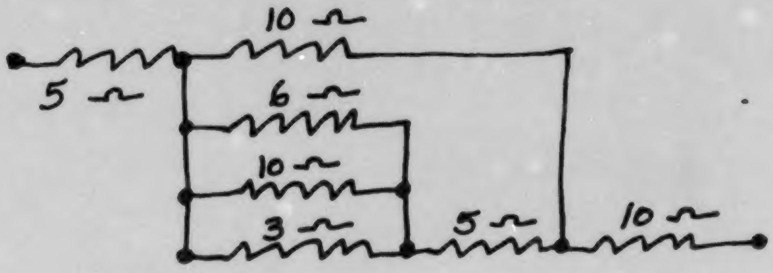
$I_{total}$ = __________

6.


50 Ω
50 Ω
200 Ω
150 Ω

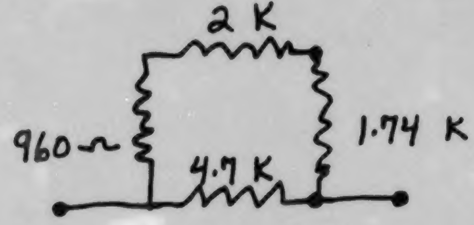
$R_{total}$ = __________ (1 point)

7.


10 Ω
5 Ω
6 Ω
10 Ω
3 Ω
5 Ω
10 Ω

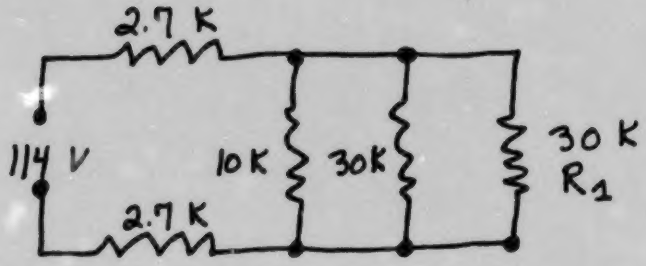
$R_{total}$ = __________ (1 point)

8.


2 K
960 Ω
1.74 K
4.7 K

$R_{total}$ = ________________ (1 point)

9.


2.7 K
114 V
10 K
30 K
30 K
$R_1$
2.7 K

$R_{total}$ = ________________

(3 points)

Itotal = ________________

Voltage across $R_1$ = ________________

PS 170
BASIC ELECTRONICS
Math Problems

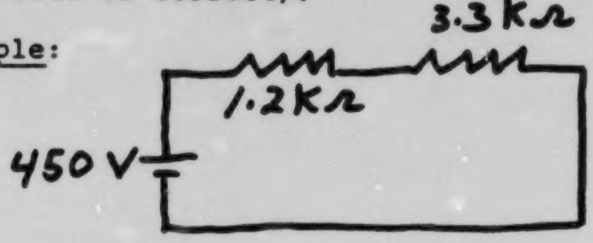
Assignment #8
68 points

Name________________

Directions: Place the requested response in the blanks provided. Show all work used to arrive at your answer. This includes the basic formula, the substitution of numbers into the formula and the steps/procedures used to arrive at your response. One point will be deducted from each response if work is not shown.

All responses must be in correct values and labeled as to the unit the number represents. (i.e. .135 A is incorrect, 135 mA is correct.) One point will be deducted from each response with incorrect values. Responses with missing or incorrectly labeled unit values (ohm, volts, amps, etc.) will be marked totally wrong. (i.e. 625 is incorrect, 625 volts is correct).

Example:



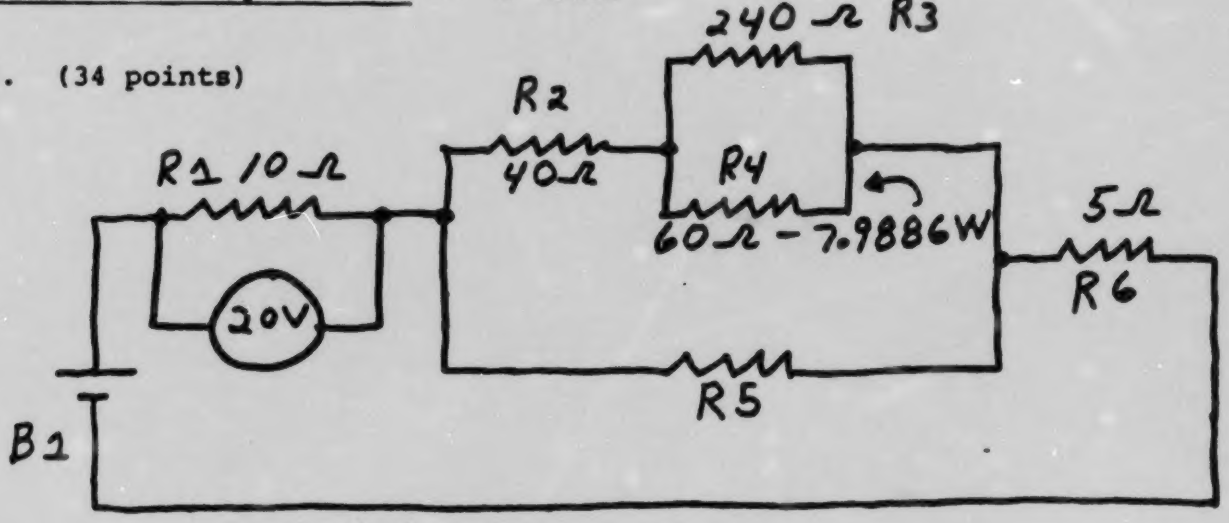
$R_t = 1.2k\Omega + 3.3k\Omega = \underline{4.5k\Omega}$

$I = \frac{E}{R} = \frac{450V}{4500\Omega} = .1A = 100mA$

4.5 kΩ = R total

100 mA = I total

1. (34 points)



________________ I through $R_1$

________________ P dissipated by $R_1$

________________ I through $R_2$

________________ P dissipated by $R_2$

________________ V across $R_2$

E #1A - page 2

1. (cont.)

____________________ I through $R_3$

____________________ V across $R_3$

____________________ I through $R_4$

____________________ V across $R_4$

____________________ I through $R_5$

____________________ V across $R_5$

____________________ $R_5$ resistance

____________________ P dissipated by $R_5$

____________________ I through $R_6$

____________________ V across $R_6$

____________________ $B_1$ voltage

____________________ P total

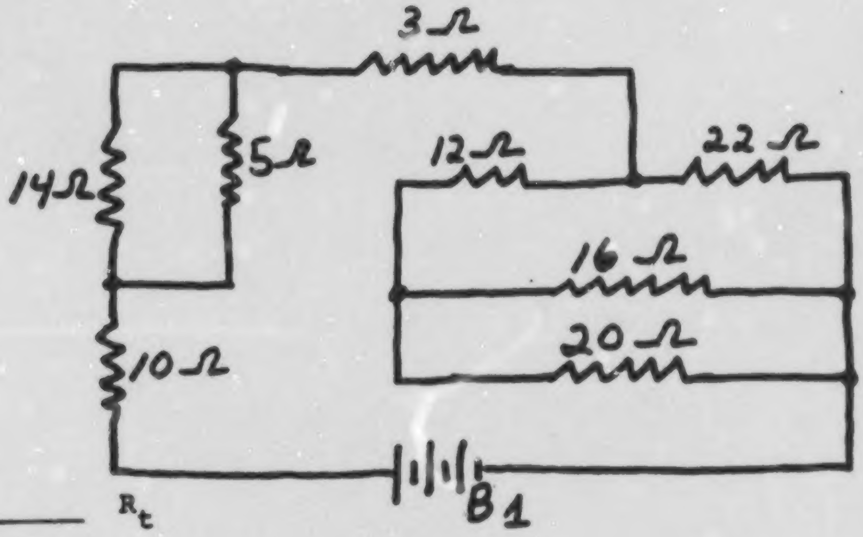
2. (6 points)

Resistors of 14, 6 and 7 ohms are connected in series with a 15 volt source.

____________________ $R_t$

____________________ $I_t$

3. (5 points)


3 Ω
14 Ω
5 Ω
12 Ω
22 Ω
16 Ω
20 Ω
10 Ω
B1

____________________ $R_t$

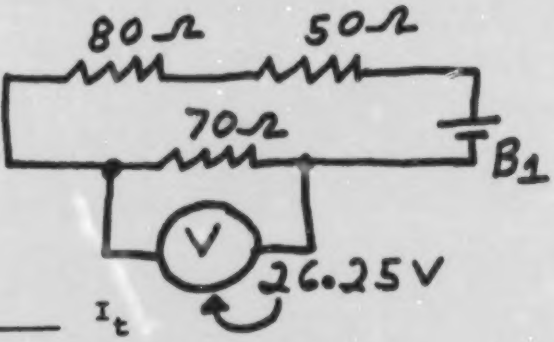
4. (6 points)

A circuit contains sixteen 100 watt 10 k ohm resistors connected across a 455 volt battery. Find the following:

____________________ $R_t$

____________________ $P_t$

5. (6 points)


80 Ω
50 Ω
70 Ω
B1
V
26.25 V

____________________ $I_t$

____________________ $B_1$ voltage

6. (5 points)

A meter movement with a full scale sensitivity of 100 $\mu$A has an internal resistance of 1250 ohms. The shunt resistance required to result in a 0 to 10 mA range is:

____________________ $R_{shunt}$

7. (3 points)

The power dissipation of a 3.3 k ohm resistor is 12 watts. The maximum allowable current through the resistor that will not exceed the resistor rating is:

____________________ I

8. (3 points)

Using the data in question number seven, determine the maximum allowed voltage that may be placed across the resistor without exceeding the dissipation rating of the resistor.

____________________ V

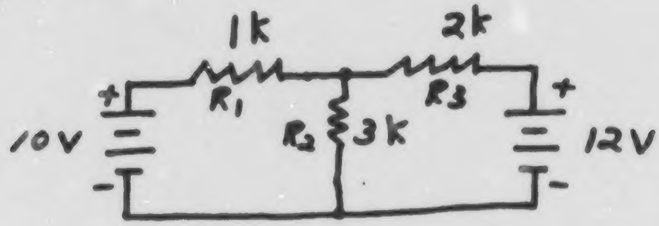
PS 170
Basic Electronics
SUPERPOSITION THEORAM

Assignment #9
25 Points

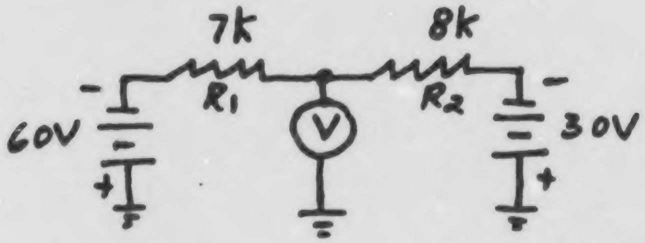
Name__________________________

Use the Superposition Theorem to solve the below problems. Each problem is worth five points. Show all math.

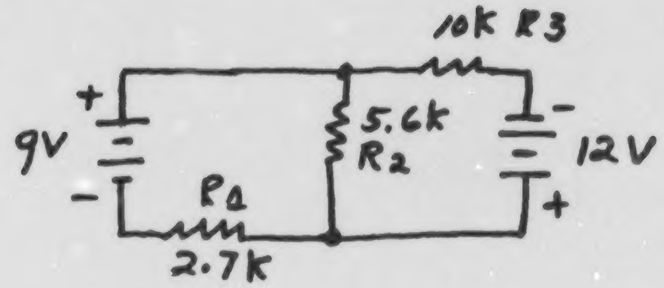
1. $E_{R_2}$=________________


1k
2k
+
R1
R3
+
10V
R2
3k
12V
-
-

2. V=________________


7k
8k
-
R1
R2
-
60V
V
30V
+
+

3. $E_{R_2}$=________________

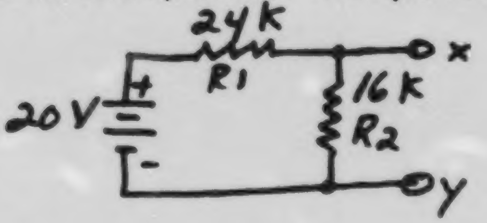

10k R3
+
-
9V
5.6k
R2
12V
-
R1
+
2.7k

PS 170
Basic Electronics
THEVENIN'S & NORTON'S THEOREM

Assignment #10
120 points

Name ____________________

Use Thevenin's Theorem to solve the below problems. Four points per answer. Show all math.


24k
R1
x
20V
+
-
16k
R2
y

1. $E_{th}$ ____________

$R_{th}$ ____________

2. In the above problem add a resistive load of 10k ohms.

$E_{RL}$ ____________

$I_{RL}$ ____________

$P_{RL}$ ____________

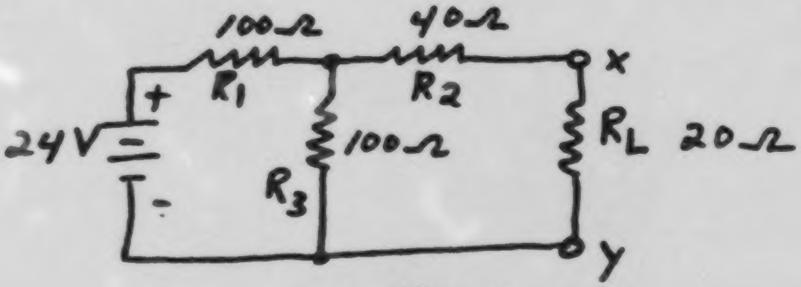
3. $E_{th}$ ____________

$R_{th}$ ____________

$E_{RL}$ ____________

$I_{RL}$ ____________

$P_{RL}$ ____________

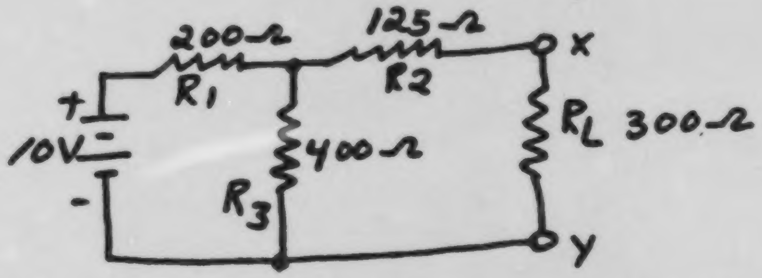

100 Ω
R1
40 Ω
R2
x
+
24V
-
100 Ω
R3
RL 20 Ω
y

4. $E_{th}$ ____________

$R_{th}$ ____________

$E_{RL}$ ____________

$P_{RL}$ ____________

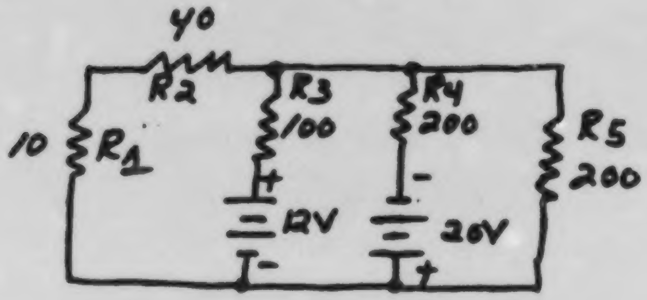

200 Ω
R1
125 Ω
R2
x
+
10V
-
400 Ω
R3
RL 300 Ω
y

In problem number four you have solved RL for 300 ohms. Now solve for the below if RL is changed to 10k ohms.

$E_{RL}$ ____________

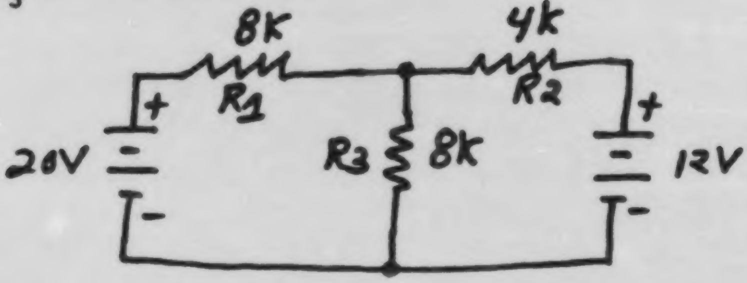
$P_{RL}$ ____________

4. $E_{R_5}$ = ____________________


40
R2
R3
100
R4
200
R5
200
10
R1
+
-
12V
-
+
20V

5. $E_{R_2}$ = ____________________

$E_{R_3}$ = ____________________


8K
R1
4k
R2
+
20V
-
R3
8k
+
12V
-

Assignment #10 Cont.

Use Norton's Theorem to solve the below problems. Show all math.

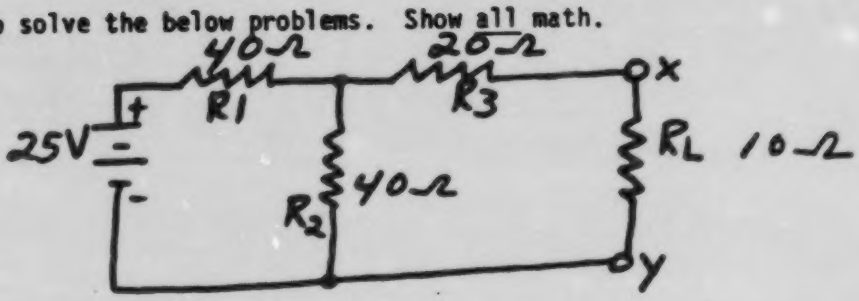
5. $R_N$ ______________

$I_{R_1}$ ______________

$I_N$ ______________

$E_{RL}$ ______________

$I_{RL}$ ______________


40Ω
20Ω
R1
R3
x
+
25V
-
R2
40Ω
RL 10Ω
y

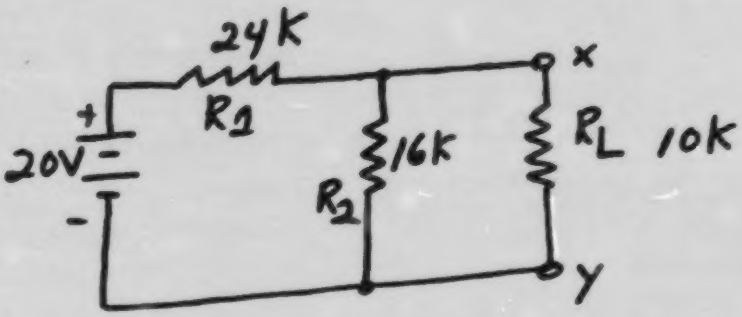
6. $R_N$ ______________

$I_{R_1}$ ______________

$I_N$ ______________

$E_{RL}$ ______________

$I_{RL}$ ______________

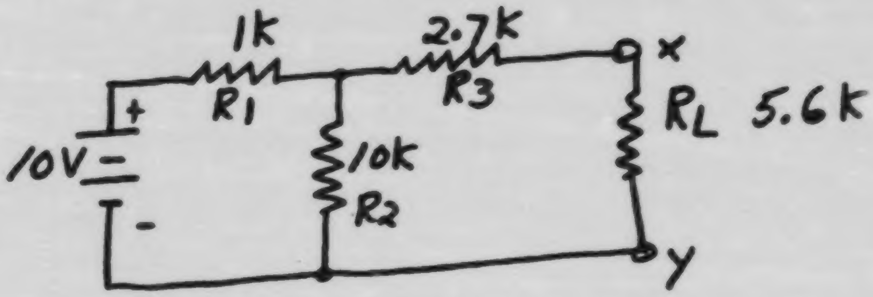

24K
x
+
R1
20V
-
16K
R2
RL 10K
y

7. $R_N$ ______________

$I_N$ ______________

$E_{RL}$ ______________

$I_{RL}$ ______________


1K
2.7K
x
+
R1
R3
10V
-
10K
R2
RL 5.6K
y

PS 170
BASIC ELECTRONICS
CAPACITIVE REACTANCE

ASSIGNMENT #11
15 points

Name ____________________________

Use the Capacitive Reactance formula to solve the below problems. Note: Other formulas will be necessary to solve for the requested unknowns. Show ALL math. One point per answer.

1. What is the capacitive reactance of a 25uf capacitor at a frequency of 750Hz.
2. What is the reactance of a 75p$^P$ at a frequency of 432 MHz.
3. A filter capacitor in a radio transmitter has a capacitance of .0025uf. What is its reactance at a frequency of 1450 kHz.
4. How much current will flow in a 7jf capacitor when 120 volts at 400 Hz is impressed across it.
5. When 120 volts at 60Hz is connected across at capacitor 210ma of current flows. What is the value of the capacitor.
6. A current of 1.75 amp at 500Hz flows through a 4uf capacitor. What is the voltage across the capacitor.
7. Two capacitors of 8 and 4uf are connected in series across a 180 volt 120Hz source. What is the current flow through the capacitors. (3 points) What is the voltage across each capacitor.
8. Two capacitors of 50uuf and 200uuf are connected in parallel. A current of 500ma at 3,500kHz flows through the 200uuf capacitor. How much current flows through the 50uuf capacitor. What is the voltage across the capacitors. (2 points)
9. A capacitor is connected across 220 volts at 60Hz. A milliammeter is connected in series with the capacitor and reads 550ma. What is the value of the capacitor.
10. A circuit operating at 200Hz contains two series capacitors of 10uf and 5uf. What is the capacitive reactance total for the circuit.
11. A .01uf capacitor in a 560 volt circuit has an $X_C$ of 100k ohms. At what frequency is this capacitor operating at.
12. An unknown value of capacitor operates in a circuit at 785 volts at a frequency of 3.8MHz with an value of $X_C$ at 122 ohms. The value of the capacitor is.

PS 170
Basic Electronics
RESISTANCE

Lab #1
VOM-Resistance
10 points

Name____________________

____________________

____________________

Using the ten given resistors, measure the values using the VOM. Values many be placed in any order.

| | MARKED VALUE | VOM VALUE | METER MULTIPLER |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |
| 5. | | | |
| 6. | | | |
| 7. | | | |
| 8. | | | |
| 9. | | | |
| 10. | | | |

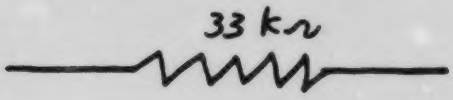
PS 170
BASIC ELECTRONICS
VOM Measurment

Lab #2
15 points

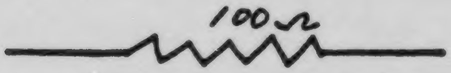
Name________________________

Name________________________

Complete this lab by using a VOM and the following resistors: Three 33K ohm, one 2.2K ohm and one 100 ohm. Connect the circuits as indicated using the proto-board. Measure the total resistance and record your answer in the space provided.



________



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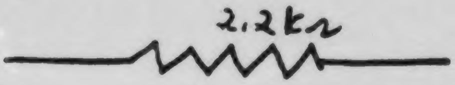

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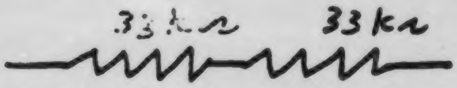

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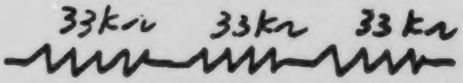
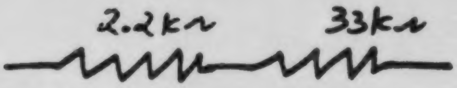
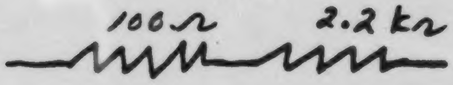

33kΩ
33kΩ
33 kΩ

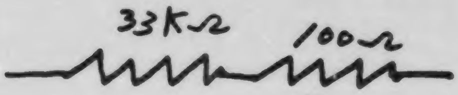
________



________

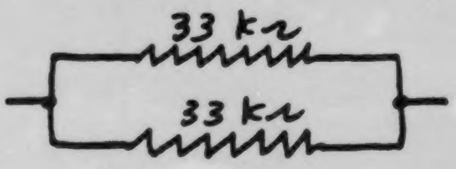


________

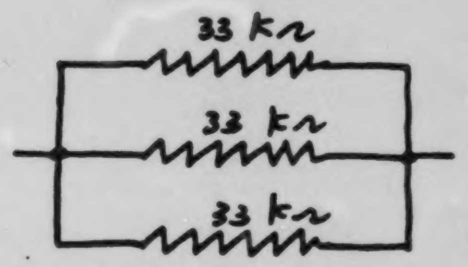


________

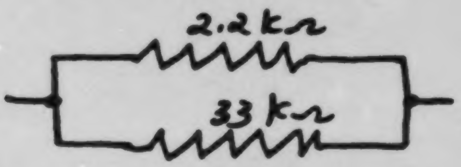
—HAND TO HAND — ________



________


33 kΩ
33 kΩ
33 kΩ

________



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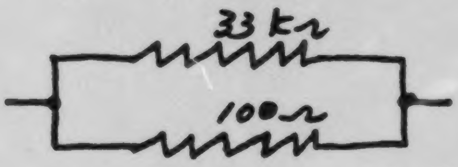

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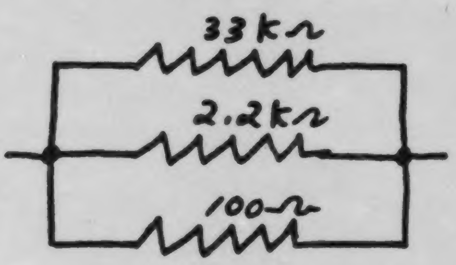
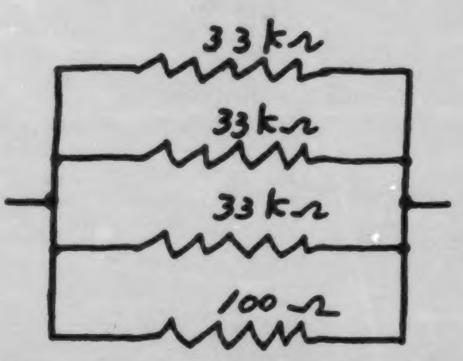

33 kΩ
2.2kΩ
100Ω

________


33 kΩ
33kΩ
33 kΩ
100 Ω

________

PS 170
BASIC ELECTRONICS
Circuit Construction

Lab #3
120 points

**Name**________________________

**Name**________________________

Transfer the caculated information from Assignment #6 to the proper locations on this sheet. Build up the circuit using your selected resistance values on proto-board. Connect a VOM into the circuit to measure current and a DMM to measure voltage drops and resistances. Apply your selected power supply voltage and record the values as requested.

Circuit #1 operates in a normal fashion.

**CACULATED**

$R_1$ ________ $R_5$ ________
$R_2$ ________ $R_6$ ________
$R_3$ ________ $R_7$ ________
$R_4$ ________ $R_8$ ________
*R total ________

$I_A$ ________ $I_D$ ________
$I_B$ ________ $I_E$ ________
IC ________

E supply ______ $E_{R_5}$ ________
$E_{R_1}$ ________ $E_{R_6}$ ________
$E_{R_2}$ ________ $ER_7$ ________
$E_{R_3}$ ________ $E_{R_8}$ ________
$E_{R_4}$ ________

$P_{R_1}$ ________ $P_{R_6}$ ________
$P_{R_2}$ ________ $P_{R_7}$ ________
$P_{R_3}$ ________ $P_{R_8}$ ________
$P_{R_4}$ ________ P total ________
$P_{R_5}$ ________

* equivalent total circuit resistance

**MEASURED**

$R_1$ ________ $R_5$ ________
$R_2$ ________ $R_6$ ________
$R_3$ ________ $R_7$ ________
$R_4$ ________ $R_8$ ________
*R total ________

$I_A$ ________ $I_D$ ________
$I_B$ ________ $I_E$ ________
IC ________

E supply ______ $E_{R_5}$ ________
$E_{R_1}$ ________ $E_{R_6}$ ________
$E_{R_2}$ ________ $ER_7$ ________
$E_{R_3}$ ________ $E_{R_8}$ ________
$E_{R_4}$ ________

$P_{R_1}$ ________ $P_{R_6}$ ________
$P_{R_2}$ ________ $P_{R_7}$ ________
$P_{R_3}$ ________ $P_{R_8}$ ________
$P_{R_4}$ ________ P total ________
$P_{R_5}$ ________

* equivalent total circuit resistance

Lab #3 Cont.

Circuit #1 has $R_2$ removed. E supply stays the same as in the first example.

**CACULATED**

*R total ________

E supply ________

$E_{R1}$ ________ $E_{R5}$ ________

$E_{R2}$ ________ $E_{R6}$ ________

$E_{R3}$ ________ $E_{R7}$ ________

$E_{R4}$ ________ $E_{R8}$ ________

$I_A$ ________

$I_B$ ________ $I_D$ ________

$I_C$ ________ $I_E$ ________

$P_{R1}$ ________

$P_{R2}$ ________ $P_{R6}$ ________

$P_{R3}$ ________ $P_{R7}$ ________

$P_{R4}$ ________ $P_{R8}$ ________

$P_{R5}$ ________ P total ________

**MEASURED**

*R total ________

E supply ________

$E_{R1}$ ________ $E_{R5}$ ________

$E_{R2}$ ________ $E_{R6}$ ________

$E_{R3}$ ________ $E_{R7}$ ________

$E_{R4}$ ________ $E_{R8}$ ________

$I_A$ ________

$I_B$ ________ $I_D$ ________

$I_C$ ________ $I_E$ ________

$P_{R1}$ ________

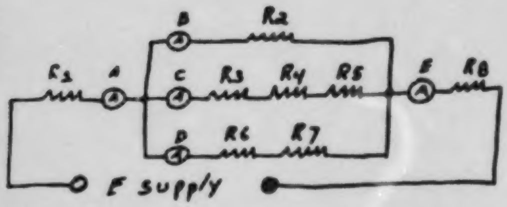
$P_{R2}$ ________ $P_{R6}$ ________

$P_{R3}$ ________ $P_{R7}$ ________

$P_{R4}$ ________ $P_{R8}$ ________

$P_{R5}$ ________ P total ________

In the above example state the reasons or reason why there was a change in total curcuit current when $R_2$ was removed from the circuit. (5 points)



Lab #3 Cont.

Circuit #1 has $R_2$ shorted. E supply stays the same as in the first normal circuit.

**CACULATED**

*R total ________

E supply ________

$E_{R1}$ ________ $E_{R5}$ ________

$E_{R2}$ ________ $E_{R6}$ ________

$E_{R3}$ ________ $E_{R7}$ ________

$E_{R4}$ ________ $E_{R8}$ ________

$I_A$ ________

$I_B$ ________ $I_D$ ________

$I_C$ ________ IE ________

$P_{R1}$ ________

$P_{R2}$ ________ $P_{R6}$ ________

$P_{R3}$ ________ $P_{R7}$ ________

$P_{R4}$ ________ $P_{R8}$ ________

$P_{R5}$ ________ P total ________

**MEASURED**

*R total ________

E supply ________

$E_{R1}$ ________ $E_{R5}$ ________

$E_{R2}$ ________ $E_{R6}$ ________

$E_{R3}$ ________ $E_{R7}$ ________

$E_{R4}$ ________ $E_{R8}$ ________

$I_A$ ________

$I_B$ ________ $I_D$ ________

$I_C$ ________ IE ________

$P_{R1}$ ________

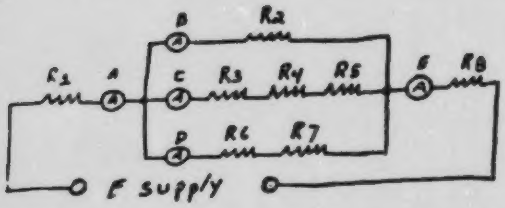
$P_{R2}$ ________ $P_{R6}$ ________

$P_{R3}$ ________ $P_{R7}$ ________

$P_{R4}$ ________ $P_{R8}$ ________

$P_{R5}$ ________ P total ________

In the above example state the reasons or reason why there was a change in circuit current and voltage drops when $R_2$ was replaced with a short. (5 points)



Circuit #1 has $R_8$ removed. E supply shall not be altered.

**CACULATED**

*R total ________

E supply ________

$E_{R1}$ ________ $E_{R5}$ ________

$E_{R2}$ ________ $E_{R6}$ ________

$E_{R3}$ ________ $E_{R7}$ ________

$E_{R4}$ ________ $E_{R8}$ ________

$I_A$ ________

$I_B$ ________ $I_D$ ________

$I_C$ ________ $I_E$ ________

$P_{R1}$ ________

$P_{R2}$ ________ $P_{R6}$ ________

$P_{R3}$ ________ $P_{R7}$ ________

$P_{R4}$ ________ $P_{R8}$ ________

$P_{R5}$ ________ P total ________

**MEASURED**

*R total ________

E supply ________

$E_{R1}$ ________ $E_{R5}$ ________

$E_{R2}$ ________ $E_{R6}$ ________

$E_{R3}$ ________ $E_{R7}$ ________

$E_{R4}$ ________ $E_{R8}$ ________

$I_A$ ________

$I_B$ ________ $I_D$ ________

$I_C$ ________ $I_E$ ________

$P_{R1}$ ________

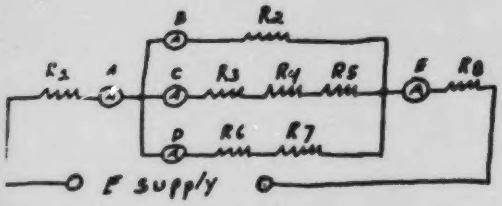
$P_{R2}$ ________ $P_{R6}$ ________

$P_{R3}$ ________ $P_{R7}$ ________

$P_{R4}$ ________ $P_{R8}$ ________

$P_{R5}$ ________ P total ________

In the above circuit state the reasons or reason for the changes in current and voltage drops, especially the measured drop across $R_8$ when $R_8$ is removed from the circuit. (5 points)



# PS 170
# BASIC ELECTRONICS
## Voltage Measurement

Lab #4
75 points

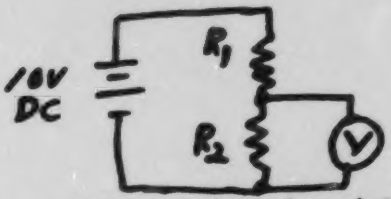
Name____________________________

Name____________________________

OBJECTIVE: To measure the voltage across a known resistor in a voltage divider circuit using various types of metering.

EQUIPMENT: Sargent-Welch DC voltmeter, Simpson VOM, Keithley DVM, Heath power supply, Proto-board

CIRCUIT:



$R_1 = R_2$

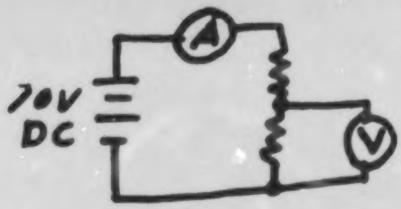
PROCEDURE: Select pairs of resistors of the indicated values that match or nearly match using the DVM. Build up the voltage divider circuit and apply ten volts. Check voltage with the DVM. Measure the voltage drop across $R_2$ for each resistance value and meter type. Record your answer in the space provided.

| (36 points) | SW | VOM | DVM |
|---|---|---|---|
| 100 ohm | | | |
| 1K | | | |
| 4.7K | | | |
| 8.2K | | | |
| 10K | | | |
| 20K | | | |
| 30K | | | |
| 47K | | | |
| 75K | | | |
| 100K | | | |
| 1M | | | |
| 10M | | | |

PROCEDURE: Rebuild each circuit to include the use of the DVM to measure circuit current. Measure current totals with only $R_1$ and $R_2$ in the circuit, then add each voltmeter and again measure total circuit current. Record your answers in the space provided.

Lab #4 Cont.

CIRCUIT:



$R_1 = R_2$

| (18 points) | $I_t$ with SW | $I_t$ with VOM | $I_t$ w/o Metering |
|---|---|---|---|
| 100 ohm | | | |
| 4.7K | | | |
| 10K | | | |
| 30K | | | |
| 100K | | | |
| 1M | | | |

PROCEDURE: Respond to the following questions concering the just completed lab.

1. Did the voltage across $R_1$ and $R_2$ remain equally divided throughout the entire Lab? If yes skip to question number three. If no answer question number two. (1 point)

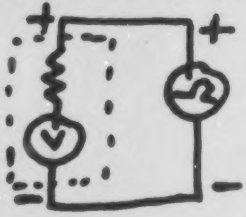
2. What reason can be given to explain the change in voltage divider behavior. (6 points)

3. When measuring currents, what explaination can be given to justify the variations of total circuit current with the various meters and differing voltage divider resistance values. (6 points)

Lab #4 Cont.

PROCEDURE: Using a DVM measure the resistance of the VOM-10 volt scale and the Sargent-Welch-30 volt scale. Record the answers in the space provided.

| (2 points) | SW | VOM |
|---|---|---|
| OHMS | | |



4. What significance does this resistance data have on the voltage divider circuit when either of these meters are used in the circuit. (6 points)

## PS 170
## Basic Electronics
## SUPERPOSITION THEOREM

Lab #5
100 points

Name________________________

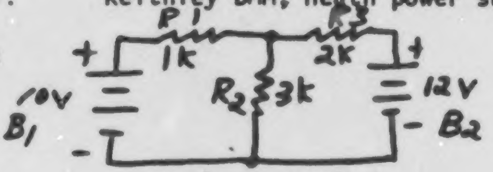
Name________________________

**INTRODUCTION:** Assignment number nine required the use of the Superposition Theorem and Ohm's Law to calculate the value of a voltage drop across indicated resistors. This lab will utilize the same basic diagrams and apply the practical circuit to Superposition Theorem.

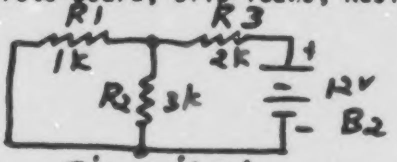
**OBJECTIVE:** To confirm by experimentation that the calculated values using the Superposition Theorem are accurate.

**EQUIPMENT:** Keithley DMM, Heath power supply, Proto-Board, Clip leads, Resistors.

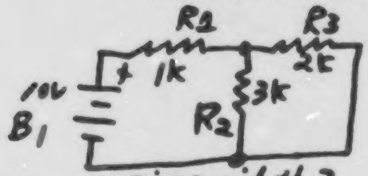
**CIRCUITS:**



Circuit #1



Circuit #2



circuit #3

**GENERAL PROCEDURE:** Build up each circuit as indicated by using parallel and series combinations of resistors to achieve the requested resistor values. (+ or - 5%) Record the actual values used to arrive at the desired resistances and the actual resultant resistance. Use the dual mode function on the power supplies in place of the batteries. Use the DMM to measure all voltages and currents.

Construct the basic circuit using the values of voltage and resistance as indicated. Then, as in the mathematical model remove one supply at a time and reconnect the open leads to their proper points. Record all values as indicated in the space provided. Diagram your actual circuit and label all used resistors.

**PROCEDURE:** Measure the actual values used in circuit number one.

$R_1$____________ $R_3$____________

$R_2$____________

**PROCEDURE:** Construct Circuit number two and record the values as indicated.

$B_2$ ____________ $I_{R_1}$ ____________

$E_{R_1}$ ____________ $I_{R_2}$ ____________

$E_{R_2}$ ____________ $I_{R_3}$ ____________

$E_{R_3}$ ____________

**PROCEDURE:** Construct Circuit number three and record the values as indicated.

$B_1$ ____________ $I_{R_1}$ ____________

$E_{R_1}$ ____________ $I_{R_2}$ ____________

$E_{R_2}$ ____________ $I_{R_3}$ ____________

$E_{R_3}$ ____________

**PROCEDURE:** Construct Circuit number one and record the values as indicated.

$B_1$ ____________ $E_{R_3}$ ____________

$B_2$ ____________ $I_{R_1}$ ____________

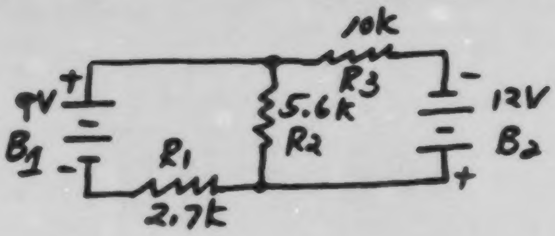
$E_{R_1}$ ____________ $I_{R_2}$ ____________

$E_{R_2}$ ____________ $I_{R_3}$ ____________

**PROCEDURE:** Draw the circuit actually used for diagram number one. Label and include in the diagram all the resistors used to arrive at the parallel and series combinations for $R_1$ through $R_3$. (5 points)

**QUESTION:** In working through the first example which parts of the experimental model agree or disagree with the mathematical model. Explain any parts that did not agree as to WHY they disagreed. (12 points)

CIRCUIT:



PROCEDURE: Construct the basic circuit and record the values as indicated.

$B_1$ __________

$B_2$ __________

$R_1$ __________

$R_2$ __________

$R_3$ __________

$E_{R_1}$ __________

$E_{R_2}$ __________

$E_{R_3}$ __________

$I_{R_1}$ __________

$I_{R_2}$ __________

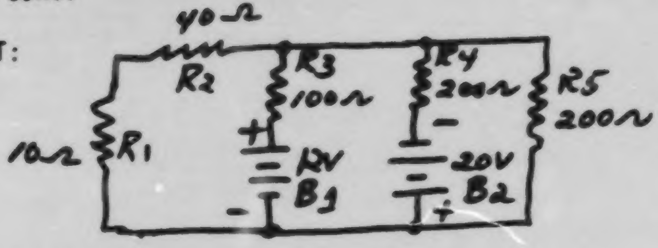
$I_{R_3}$ __________

PROCEDURE: Draw the circuit actually used in the above problem. Label and include in the diagram all the resistors used to arrive at the parallel and series combinations of $R_1$ through $R_3$. (5 points)

CIRCUIT:

QUESTION: Did the above measured circuit values agree with the calculated values? If not, explain. (5 points)

CIRCUIT:



PROCEDURE: Construct the basic circuit and record the values as indicated.

$B_1$ ____________

$B_2$ ____________

$R_1$ ____________

$R_2$ ____________

$R_3$ ____________

$R_4$ ____________

$R_5$ ____________

$E_{R_1}$ ____________

$E_{R_2}$ ____________

$E_{R_3}$ ____________

$E_{R_4}$ ____________

$E_{R_5}$ ____________

$I_{R_1}$ ____________

$I_{R_2}$ ____________

$I_{R_3}$ ____________

$I_{R_4}$ ____________

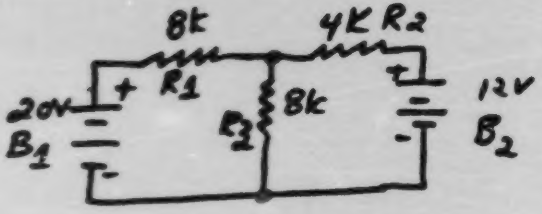
$I_{R_5}$ ____________

PROCEDURE: Draw the circuit actually used in the above problem. Label and include in the diagram all the resistors used to arrive at the parallel and series combinations of $R_1$ thorugh $R_5$. (5 points)

CIRCUIT:

QUESTION: Did the above measured circuit values agree with the calculated values? If not, explain. (5 points)

CIRCUIT:



PROCEDURE: Construct the basic circuit and record the values as indicated.

$B_1$ ____________

$B_2$ ____________

$R_1$ ____________

$R_2$ ____________

$R_3$ ____________

$E_{R_1}$ ____________

$E_{R_2}$ ____________

$E_{R_3}$ ____________

$I_{R_1}$ ____________

$I_{R_2}$ ____________

$I_{R_3}$ ____________

PROCEDURE: Draw the circuit actually used in the above problem. Label and include in the diagram all the resistors used to arrive at the parallel and series combinations of $R_1$ through $R_3$. (5 points)

CIRCUIT:

QUESTION: Did the above measured circuit values agree with the calculated values? If not, explain. (5 points)

PS 170
Basic Electronics
OSCILLOSCOPE/FUNCTION GENERATOR

Lab #6
135 points

Name_________________________

Name_________________________

OBJECTIVE: To become familiar with the characteristics and operation of both the function generator and oscilloscope.

EQUIPMENT: Dual-Trace Oscilloscope, Function Generator, Simpson VOM, Keithley DVM

PROCEDURE: Connect the scope probe to the 600 ohm and ground outputs of the function generator. Set the controls on the function generator as indicated and record the requested data. When using the DVM and VON also use the 600 ohm and ground function generator outputs. Draw the displayed waveform labeling the voltages and the waveforms referenced to zero.

Lab # Cont.

For the below use the sine wave function on the function generator.

| Range | Frequency | Amplitude | Offset | AC-PP Volts | Measured Frequency | AC Volts DVM | AC Volts VOM | Diagram Waveform |
|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 9 | Full- | | | | | |
| 1 | 5 | 9 | Center | | | | | |
| 1 | 5 | 9 | Full+ | | | | | |
| 1 | 5 | 12 | Full- | | | | | |
| 1 | 5 | 12 | Center | | | | | |
| 1 | 5 | 12 | Full+ | | | | | |
| 1 | 5 | Full on | Full- | | | | | |
| 1 | 5 | Full on | Center | | | | | |
| 1 | 5 | Full on | Full+ | | | | | |

Lab # Cont.

For the below use the triangle wave function on the function generator.

| Range | Frequency | Amplitude | Offset | AC-PP Volts | Measured Frequency | AC Volts DVM | AC Volts VOM | Diagram Waveform |
|---|---|---|---|---|---|---|---|---|
| 100 | 10 | 9 | Full- | | | | | |
| 100 | 10 | 9 | Center | | | | | |
| 100 | 10 | 9 | Full+ | | | | | |
| 100 | 10 | 12 | Full- | | | | | |
| 100 | 10 | 12 | Center | | | | | |
| 100 | 10 | 12 | Full + | | | | | |
| 100 | 10 | Full on | Full- | | | | | |
| 100 | 10 | Full on | Center | | | | | |
| 100 | 10 | Full on | Full+ | | | | | |

Lab # Cont.

For the below use the square wave function on the function generator.

| Range | Frequency | Amplitude | Offset | AC-PP Volts | Measured Frequency | AC Volts DVM | AC Volts VOM | Diagram Waveform |
|---|---|---|---|---|---|---|---|---|
| 100k | 10 | 9 | Full- | | | | | |
| 100k | 10 | 9 | Center | | | | | |
| 100k | 10 | 9 | Full+ | | | | | |
| 100k | 10 | 12 | Full- | | | | | |
| 100k | 10 | 12 | Center | | | | | |
| 100k | 10 | 12 | Full+ | | | | | |
| 100k | 10 | Full on | Full- | | | | | |
| 100k | 10 | Full on | Center | | | | | |
| 100k | 10 | Full on | Full+ | | | | | |

# PS 170
# BASIC ELECTRONICS
# CAPACITOR TIME CONSTANT

LAB #7
100 Points

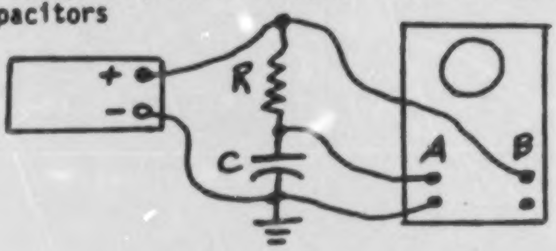
Name ______________________________

Name ______________________________

**OBJECTIVE:** To calculate the value of the charge and discharge RC time constants and then measure the actual values using an oscilloscope.

**EQUIPMENT:** Keithley DMM, Oscilloscope, Function Generator, Resistors, Capacitors

**CIRCUIT:**



**GENERAL PROCEDURE:** Connect the circuit as indicated observing the polarity when using electrolytic capacitors. Use the 600 ohm outputs of the function generator and inputs A and B on the scope. This will allow viewing of the signals across the capacitor and across the entire circuit. Set the function generator to square wave and the DC offset to a neutral position (i.e., no offset). Set both channel selector switches to AC and the mode Switch to DUAL and the probes to 10X on the scope.

**SPECIFIC PROCEDURE:** First calculate the requested data and enter into the provided spaces. Fine tune the frequency to allow a full seven time constants of the displayed waveform to appear. ($V_{zero}$ to $V_{max}$) Adjust the sweep time to obtain a readable waveform. Measure the PP voltage and record. Multiply the PP by 63.2%. Locate this point on the graticule and measure the resultant time it has taken the capacitor to charge to one TC.

**DATA:** Calculate the data using the given RC values for the first, fifth, and seventh time constants. Convert this information from the fifth TC to frequency in Hertz. Measure the resistor with the DMM. Use this value for your calculations: Measure the time duration of the first and seventh TC. Disconnect the RC circuit and use Channel B to measure the period and resultant frequency of the applied square wave. Using the measured data, calculate the actual value of the capacitor used in the circuit.

**UNKNOWN CAPACITOR:** Select a value of resistance to use as part of the RC circuit. Apply a frequency and record sufficient data to determine the value of the unknown capacitor.

Lab #7 Cont.

| | | CALCULATED DATA | | | | MEASURED DATA | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st TC | 5th TC | 7th TC | Freq 5TC | 1st TC | 7th TC | PP Volt | Res | Square Period | Applied Freq | Calculated Cap |
| CHARGE CYCLE | 1uf 100Ω | | | | | | | | | | | |
| DIS-CHARGE | 1uf 100Ω | | | | | | | | | | | |
| CHARGE CYCLE | .33uf 680Ω | | | | | | | | | | | |
| DIS-CHARGE | .33uf 680Ω | | | | | | | | | | | |
| CHARGE CYCLE | .15uf 10kΩ | | | | | | | | | | | |
| DIS-CHARGE | .15uf 10kΩ | | | | | | | | | | | |
| CHARGE CYCLE | 523pf 200kΩ | | | | | | | | | | | |
| DIS-CHARGE | 523pf 200kΩ | | | | | | | | | | | |
| UNKNOWN CAP. | | | | | | | | | | | | |

What reasons can be given to justify the differences between the marked and measured capacitor values. (5 points)

PS 170
Basic Electronics
ASTABLE TIMER

Lab #8
32 points

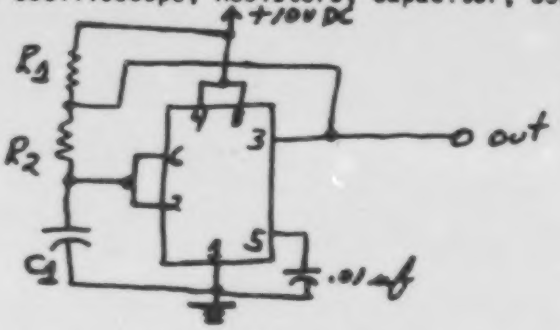
Name________________________

Name________________________

**OBJECTIVE:** To measure the waveforms generated by a 555 timer.

**EQUIPMENT:** DVM, Oscilloscope, Resistors, Capacitor, 555 Timer

**CIRCUIT:**



**PROCEDURE:** Build the circuit with $R_1$= 1k, $R_2$= 75k and $C_1$= .01uf. Set the supply voltage to 10VDC.

**FIND:** Calculate $f_o$ using $f_o = \frac{.722}{R_2C_1}$

Measure $f_o$ at pin #3 and record

Measure and record 1TC charge at pin #2

$C_1$= .01uf

$R_1$=____________

$R_2$=____________

Calculate $f_o$= ____________

Duty Cycle=______________

Frequency=______________

Pulsewidth=______________

Time between pulses=__________

1Charge TC pin #2=__________

Change R1 to 10k

$C_1$= .01uf

$R_1$=____________

$R_2$=____________

Calculate $f_o$=____________

Duty Cycle=______________

Frequency=______________

Pulsewidth=______________

Time between pulses=__________

1 Charge TC pin #2=__________

Change $C_1$ to .15uf and $R_1$ to 1k.

| | |
|---|---|
| $C_1$= .15uf | Duty Cycle=________________ |
| $R_1$=__________________ | Frequency=_________________ |
| $R_2$=_______________ | Pulsewidth=________________ |
| Calculate $f_o$=___________ | Time between pulses=____________ |
| | 1 Charge TC pin #2=_____________ |

Keep $C_1$ at .15uf and change $R_1$ to 10k.

| | |
|---|---|
| $C_1$=.15uf | Duty Cycle=_________________ |
| $R_1$=____________________ | Frequency=__________________ |
| $R_2$=___________________ | Pulsewidth=_________________ |
| Calculate $f_o$=____________ | Time between pulses=_________ |
| | 1 Charge TC pin #2=__________ |

PS 170
Basic Electronics
## SERIES RC CIRCUITS

Lab #9
120 points

Name____________________

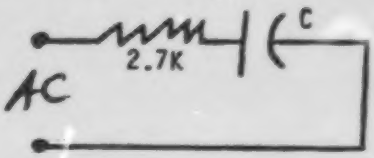
Name____________________

OBJECTIVE: To measure the AC voltage drops across a resistor and capacitor in a series RC circuit.

EQUIPMENT: Keithley DMM, Function Generator, resistor and capacitors

PROCEDURE: Apply a 5 volt AC RMS sine wave to the series RC circuit. Measure the voltage drop across C and R at each specified frequency. Recheck input voltage to maintain a 5 volt RMS generator output for every frequency and component change.

CIRCUIT:



FORMULAS: Use the following formulas to calculate from the measured data the values of $X_c$, Z and $\theta$.

$\theta \text{ arctan} = \frac{E_c}{E_r}$ $\qquad$ $X_c = R_t \times \text{Tan } \theta$ $\qquad$ $Z = \frac{X_c}{\text{Sine } \theta}$

EXPLAIN: Why the individual voltages do not add up to the source voltage. (10 points)

Why the voltage drops vary with the applied frequency. (10 points)

Why the value of the capacitor altered resultant voltages. (10 points)

Lab #9 Cont.
(1 point per answer)

| | 10Hz | 100Hz | 1kHz | 10kHz | 100kHz | 1MHz | 10kHz CACULATED | | | 10kHz MEASURED | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | $X_c$ | Z | θ | $X_c$ | Z | θ |
| 523uuf | | | | | | | | | | | | |
| 2.7K | | | | | | | | | | | | |
| .01uf | | | | | | | | | | | | |
| 2.7K | | | | | | | | | | | | |
| .15uf | | | | | | | | | | | | |
| 2.7K | | | | | | | | | | | | |
| .33uf | | | | | | | | | | | | |
| 2.7K | | | | | | | | | | | | |
| 1uf | | | | | | | | | | | | |
| 2.7K | | | | | | | | | | | | |

# ELECTRONIC MAINTENANCE TECHNOLOGY PROGRAM

## SOLID STATE ELECTRONICS

## ET 110

Learning for a Lifetime
WASHBURN UNIVERSITY
School of Applied and
Continuing Education

# ELECTRONIC MAINTENANCE TECHNOLOGY PROGRAM
## ET 110
## SOLID STATE ELECTRONICS

SCHOOL OF APPLIED AND CONTINUING EDUCATION
WASHBURN UNIVERSITY

# FORWARD

In 1983, the Vocational Administration Section of the Kansas State Department of Education provided a grant to the School of Applied and Continuing Education at Washburn University to develop a two year associate degree program in the emerging high technology field of electronics. These curriculum materials are one of the products of that project. This curriculum package includes the course syllabi, study guide, information sheets, laboratory sheets, assignments sheets and unit examinations.

The materials in this package have been prepared in a sequence that best matched our situation. The individual instructor may add, delete or rearrange to his/her own needs.

Assistant Professor, Jim Jaworski is the author of these curriculum materials and is to be congratulated for his work. Our special thanks also go to the support staff in the School for their assistance with graphics, typing and editing of these materials.

William S. Dunlap

and

Reid A. Holland
Project Directors

Funding for this project was provided through the Research Coordinating Unit, Division of Community Colleges and Vocational Education, Kansas State Department of Education under Public Law 94-482, subpart 3, section 132.

State Reference No. 85-132-03

The activity which is the subject of this report was supported in whole or in part by funds from Kansas State Department of Education, Division of Vocational and Post Secondary Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Kansas Department of Education or the Division of Community Colleges and Vocational Education, and no official endorsement should be inferred.

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# ET 110
# Solid State Electronics
3 Semester Hours

School of Applied and Continuing Education
Washburn University

Spring 1985

J. Jaworski, Professor

## INTRODUCTION

Solid State Electronics continues the study of electronics from basic ohm's law and other related fundamentals into the world of active and passive semiconductor devices. Today's world is totally reliant upon this technology from the simple diode junction to the hybrid integrated circuit. This course will explore this fascinating world of semiconductor devices both in theory and application.

## COURSE ORGANIZATION

The class will meet twice a week. On Monday evening, the class runs from 5:20 to 7:20 p.m. On Wednesday evening, the class is in session from 5:20 to 7:20 p.m. Lecture and lab sessions will be interchanged at the discretion of the instructor to best facilitate the presentation of course material.

## TENTATIVE COURSE CONTENT

The material covered in this course will basically follow the below schedule subject to needed instructor modification:

| | | | |
|---|---|---|---|
| January | 21 | Monday | Introduction |
| | 28 | Monday | Semiconductor Devices |
| | 30 | Wednesday | Semiconductor Diodes |
| February | 4 | Monday | Zener Diode |
| | 6 | Wednesday | Zener Diode continued |
| | 11 | Monday | Special Diodes |
| | 13 | Wednesday | Special Diodes continued |
| | 18 | Monday | Test #1 |
| | 20 | Wednesday | Bipolar Transistor Operation |
| | 25 | Monday | Bipolar Transistor Operation continued |
| | 27 | Wednesday | Bipolar Transistor Characteristics |
| March | 4 | Monday | Bipolar Transistor Characteristics continued |
| | 6 | Wednesday | Biasing |
| | 11 | Monday | Biasing continued |
| | 13 | Wednesday | Basic Amplifiers |
| | 18 | Monday | NO CLASSES SPRING BREAK |
| | 20 | Wednesday | NO CLASSES SPRING BREAK |
| | 25 | Monday | Basic Amplifiers |
| | 27 | Wednesday | Typical Amplifiers |

| | | | |
|---|---|---|---|
| April | 1 | Monday | Typical Amplifiers continued |
| | 3 | Wednesday | Field Effect Transistors |
| | 8 | Monday | Test #2 |
| | 10 | Wednesday | Oscillators |
| | 15 | Monday | Oscillators continued |
| | 17 | Wednesday | Pulse Circuits |
| | 22 | Monday | OP Amps |
| | 24 | Wednesday | OP Amps continued |
| | 29 | Monday | Thyristors |
| May | 1 | Wednesday | Optoelectronic Devices |
| | 6 | Monday | Power Supplies |
| | 8 | Wednesday | Power Supplies continued |
| | 15 | Wednesday | Final Examination |

## COURSE OBJECTIVES

The objectives of this course are adequately stated at the beginning of each chapter in your textbook. These objectives reflect the needs and desired outcome of this course.

## COURSE REQUIREMENTS

Text: Heath Company, Semiconductor Devices

## GRADING SCALE

All class evaluation will be based on the grading scale listed below. The indicated percentage designates the bottom of the respective grade zone, i.e., 85% is the bottom of the B's. An individual earning an 82% would receive a grade of C, etc.

| | |
|---|---|
| A | 93% |
| B | 85% |
| C | 77% |
| D | 69% |

Individual grades will not be issued during the course of the term. It is your responsibility to record all test scores and calculate any applicable letter grades. As an example: a test has 86 possible points. Your score is 76. Divide 76 by 86 and the percentage is 88.4%. The equivalent letter grade from the chart is a grade of "B".

## EVALUATION
(50% of the total grade)

All major evaluations will contribute an equal percentage regardless of the number of evaluations during the course of the term. The number of evaluations may range from two through four with the following table listing the applicable percentages:

| | |
|---|---|
| Two Evaluations | 25.0% each |
| Three Evaluations | 16.6% each |
| Four Evaluations | 12.5% each |

The Final Examination will be given as listed in the spring schedule of classes. The Final Examination date and time is: Wednesday, May 15, 1985, beginning at 5:20 p.m. and ending at 8:20 p.m. Alterations in final times and dates are possible with class, instructor and Dean's consent.

## EVALUATION REVIEW PROCEDURES

The following procedures will be utilized for the review of all major evaluations:

1. Answers will be given in class to check for mechanical grading errors. Comments regarding the agreement or disagreement to a response will not be invited at this time.

2. If a disagreement exists, follow the procedure below:

    A. On the top of the front page of the test, write the number of the question you disagree with.

    B. Locate the page on which the question you disagree with appears. On the back of this page, write your reasons why your response should be considered correct.

    C. Repeat this procedure as often as necessary.

3. Sufficient time will be provided for the individual accomplishment of step two. Those not wishing to respond are to remain silent during this period. There is to be no discussion during this period by any class members.

4. After completion of all written input, the examination will then be reviewed. All responses made during this review process will not have any bearing on any individual's grade, as only the written response will be considered.

5. During this discussion period, all writing on the examination must cease. Those continuing to respond will be considered to be cheating.

6. Individuals not participating in the test review procedures forfeit their right to alter their test score at a future date, i.e. all debate must be made in writing on the test itself.

7. Examination papers will be made available for review purposes on an individual basis. These test materials are not to leave the Instructor's office.

## LAB SHEETS
(20% of the total grade)

Laboratory experiments requiring the gathering of data through the use of electronic instrumentation or the performance of a skill in an instructor assigned learning experience in student pairs are considered to be lab work.

## ASSIGNMENT/PROBLEM SHEETS
(20% of the total grade)

Individually performed instructor assigned exercises requiring the mathematical manipulation of factors for the obtainment of correct responses, i.e., materials not requiring the use of the lab or lab experiments for the obtainment of answers.

## SENSATIONALS AND HOW ABOUTS
(10% of the total grade)

An individually prepared hand-in covering sensationals and how abouts on class activities, lecture material, reading, discussion, etc.

A sensational is a reaction to a main point or topic that the individual found exceptional or sensational in nature. A how about is a questioning reaction to presented material. How abouts indicate points that are unclear and require further discussion for clarification or offers constructive alternatives to what was presented.

## QUIZZES
(Part of the S and HA total)

Quizzes are considered to be short announced or unannounced examinations consisting of ten to twenty-five points and spaced spasmodically throughout the course. In addition, quizzes can NOT be made up. Generally, a missed quiz will result in a grade of zero being entered into the record for that particular quiz. However, each individual is allowed to miss one quiz without penalty.

## LATE POLICY

In general, materials to be handed in are due at the beginning of the class period. These materials are considered late if presented after the announced due date unless otherwise specified. Materials received late will not be graded.

If you anticipate being absent, these materials may be handed in early, delivered to my office (Room 124, Benton Hall), placed in my faculty mailbox, or presented by a fellow student during the regularly scheduled class period.

## WORK MISREPRESENTATION

All work produced is expected to be your own material. Plagiarism, cheating, or other forms of academic dishonesty are not tolerated. Those being observed in such circumstances will not receive credit for the course.

The instructor reserves the right to alter this syllabus as required.

# ET 110
# Solid State
# DIODE DATA SHEETS

## Information Sheet #1

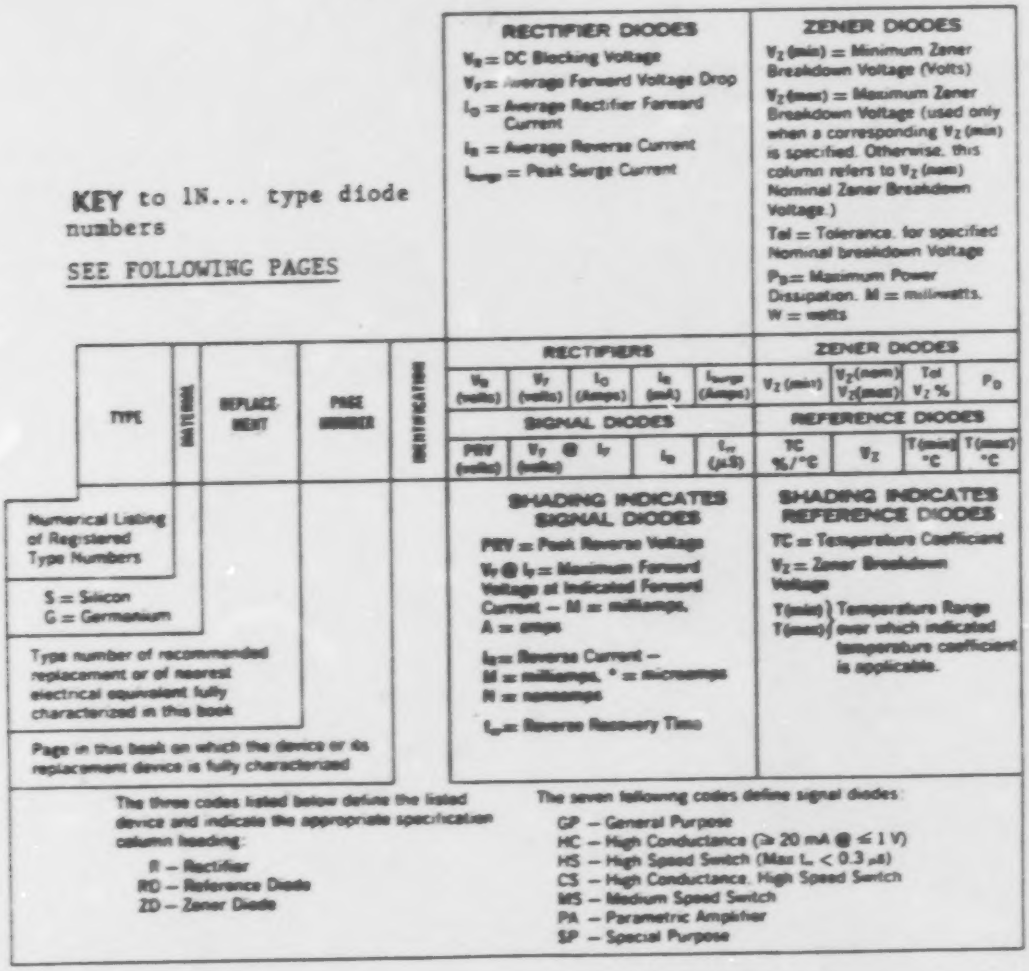
The following table lists, in numerical sequence, all EIA registered devices with 1N... type numbers, and provides major electrical specifications for these devices. Semiconductors included in this tabular listing are Rectifier Diodes, Zener Diodes, Reference Diodes, Signal Diodes and Varactor Diodes.

Since the major electrical characteristics for devices in each of the above groups differ from one another, the below table headings consists of four different sets of specifications, each applying to a specific group of devices.

THE SEMICONDUCTOR DATA BOOK by Motorola, Inc.

**KEY** to 1N... type diode numbers

SEE FOLLOWING PAGES



RECTIFIER DIODES

$V_R$ = DC Blocking Voltage
$V_F$ = Average Forward Voltage Drop
$I_O$ = Average Rectifier Forward Current
$I_R$ = Average Reverse Current
$I_{surge}$ = Peak Surge Current

ZENER DIODES

$V_Z$ (min) = Minimum Zener Breakdown Voltage (Volts)
$V_Z$ (max) = Maximum Zener Breakdown Voltage (used only when a corresponding $V_Z$ (min) is specified. Otherwise, this column refers to $V_Z$ (nom) Nominal Zener Breakdown Voltage.)
Tol = Tolerance, for specified Nominal breakdown Voltage
$P_D$ = Maximum Power Dissipation. M = milliwatts. W = watts

TYPE | MATERIAL | REPLACEMENT | PAGE NUMBER | IDENTIFICATION

RECTIFIERS: $V_R$ (volts) | $V_F$ (volts) | $I_O$ (Amps) | $I_R$ (mA) | $I_{surge}$ (Amps)

ZENER DIODES: $V_Z$ (min) | $V_Z$(nom) / $V_Z$(max) | Tol $V_Z$ % | $P_D$

SIGNAL DIODES: PRV (volts) | $V_F$ @ $I_F$ (volts) | $I_R$ | $t_{rr}$ (µS)

REFERENCE DIODES: TC %/°C | $V_Z$ | T(min) °C | T(max) °C

Numerical Listing of Registered Type Numbers

S = Silicon
G = Germanium

Type number of recommended replacement or of nearest electrical equivalent fully characterized in this book

Page in this book on which the device or its replacement device is fully characterized

SHADING INDICATES SIGNAL DIODES

PRV = Peak Reverse Voltage
$V_F$ @ $I_F$ = Maximum Forward Voltage at Indicated Forward Current — M = milliamps, A = amps
$I_R$ = Reverse Current — M = milliamps, * = microamps N = nanoamps
$t_{rr}$ = Reverse Recovery Time

SHADING INDICATES REFERENCE DIODES

TC = Temperature Coefficient
$V_Z$ = Zener Breakdown Voltage
T(min) } T(max) } Temperature Range over which indicated temperature coefficient is applicable.

The three codes listed below define the listed device and indicate the appropriate specification column heading:

R — Rectifier
RD — Reference Diode
ZD — Zener Diode

The seven following codes define signal diodes:

GP — General Purpose
HC — High Conductance (≥ 20 mA @ ≤ 1 V)
HS — High Speed Switch (Max $t_{rr}$ < 0.3 µs)
CS — High Conductance, High Speed Switch
MS — Medium Speed Switch
PA — Parametric Amplifier
SP — Special Purpose

BEST COPY AVAILABLE

— Numerical Index —

**1N3927 — 1N3994**

| TYPE | MATERIAL | REPLACEMENT | PAGE NUMBER | IDENTIFICATION | RECTIFIERS | | | | | ZENER DIODES | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | $V_R$ (volts) | $V_F$ (volts) | $I_O$ (Amps) | $I_R$ (mA) | $I_{surge}$ (Amps) | $V_Z$ (min) | $V_Z$ (nom)<br>$V_Z$ (max) | Tol $V_Z$ % | $P_D$ |
| | | | | | SIGNAL DIODES | | | | | REFERENCE DIODES | | | |
| | | | | | PRV (volts) | $V_F$ @ (volts) | $I_F$ | $I_R$ | $t_{rr}$ (µS) | TC %/°C | $V_Z$ | T(min) °C | T(max) °C |
| 1N3927 | S | | | R | 2500 | 2 | 10 | .5 | 100 | | | | |
| 1N3928 | S | | | R | 3000 | 2 | 10 | .5 | 100 | | | | |
| 1N3929 | S | | | GP | 1000 | 2 | 1A | 10• | | | | | |
| 1N3930 | S | | | GP | 1500 | 2 | 1A | 10• | | | | | |
| 1N3931 | S | | | GP | 2000 | 2 | 1A | 10• | | | | | |
| 1N3932 | S | | | GP | 1500 | 2 | 1A | 10• | | | | | |
| 1N3933 | S | | | GP | 3000 | 2 | 1A | 10• | | | | | |
| 1N3934 | S | | | R | 1200 | 2.5 | 1 | .4 | 50 | | | | |
| 1N3938 | S | | | R | 200 | 1.1 | 2 | .2 | 30 | | | | |
| 1N3939 | S | | | R | 400 | 1.1 | 2 | .2 | 30 | | | | |
| 1N3940 | S | | | R | 600 | 1.1 | 2 | .2 | 30 | | | | |
| 1N3941 | S | | | R | 800 | 1.5 | 2 | .2 | 30 | | | | |
| 1N3942 | S | | | R | 1000 | 1.5 | 2 | .2 | 30 | | | | |
| 1N3943 | S | | | GP | 3 | 2.5 | 300M | 100• | | | | | |
| 1N3944 | G | | | GP | 15 | .75 | 10M | 2.5• | 12 | | | | |
| 1N3945<br>thru<br>1N3947 | | Varactor Diodes, see table on page 1-99 | | | | | | | | | | | |
| 1N3949 | S | | | ZD | | | | | | | 20.0 | 5 | 10W |
| 1N3950 | S | | | ZD | | | | | | | 20.0 | 5 | 1.5W |
| 1N3951 | S | | | ZD | | | | | | | 25.0 | 5 | 1.5W |
| 1N3952 | S | | | GP | 130 | .74 | 10M | 25M | | | | | |
| 1N3953 | G | | | MS | 40 | .5 | 35M | 50• | 300 | | | | |
| 1N3954 | S | | | CS | 50 | 1 | 200M | .1• | 4 | | | | |
| 1N3955 | S | | | R | 100 | 1.3 | 70 | 15 | 1200 | | | | |
| 1N3956 | S | | | HS | 40 | .55 | 100• | .05• | 2 | | | | |
| 1N3957 | S | | | GP | 1000 | 1 | 400M | 10• | | | | | |
| 1N3958 | S | | | R | 100 | 1.3 | 3.5 | .4 | 35 | | | | |
| 1N3959 | S | | | R | 200 | 1.3 | 3.5 | .4 | 35 | | | | |
| 1N3960 | S | | | R | 300 | 1.3 | 3.5 | .4 | 35 | | | | |
| 1N3961 | S | | | R | 400 | 1.3 | 3.5 | .4 | 35 | | | | |
| 1N3962 | S | | | R | 500 | 1.3 | 3.5 | .4 | 35 | | | | |
| 1N3963 | S | | | R | 600 | 1.3 | 3.5 | .4 | 35 | | | | |
| 1N3964 | S | | | R | 200 | 1.6 | 22 | 1 | 200 | | | | |
| 1N3965 | S | | | R | 400 | 1.6 | 22 | 1 | 200 | | | | |
| 1N3966 | S | | | R | 600 | 1.6 | 22 | 1 | 200 | | | | |
| 1N3967 | S | | | R | 800 | 1.6 | 22 | 1 | 200 | | | | |
| 1N3968 | S | | | R | 200 | 1.6 | 50 | 2 | 600 | | | | |
| 1N3969 | S | | | R | 400 | 1.6 | 50 | 2 | 600 | | | | |
| 1N3970 | S | | | R | 600 | 1.6 | 50 | 2 | 600 | | | | |
| 1N3971 | S | | | R | 800 | 1.6 | 50 | 2 | 600 | | | | |
| 1N3972 | S | | | R | 200 | 1.5 | 104 | 5 | 1500 | | | | |
| 1N3973 | S | | | R | 400 | 1.5 | 104 | 5 | 1500 | | | | |
| 1N3974 | S | | | R | 600 | 1.5 | 104 | 5 | 1500 | | | | |
| 1N3975 | S | | | R | 800 | 1.5 | 104 | 5 | 1500 | | | | |
| 1N3976 | S | | | R | 200 | 1.5 | 250 | 10 | 4000 | | | | |
| 1N3977 | S | | | R | 400 | 1.5 | 250 | 10 | 4000 | | | | |
| 1N3978 | S | | | R | 600 | 1.5 | 250 | 10 | 4000 | | | | |
| 1N3979 | S | | | R | 800 | 1.5 | 250 | 10 | 4000 | | | | |
| 1N3981 | S | | | HC | 200 | 1 | 900M | .01M | | | | | |
| 1N3982 | S | | | HC | 400 | 1 | 900M | .01M | | | | | |
| 1N3983 | S | | | HC | 600 | 1 | 900M | .01M | | | | | |
| 1N3984 | S | | | ZD | | | | | | | 5.5 | 5 | 10W |
| 1N3985 | S | | | ZD | | | | | | | 6 | 5 | 10W |
| 1N3986 | S | | | ZD | | | | | | | 6.2 | 5 | 10W |
| 1N3987 | S | | | R | 700 | 1.4 | 6 | .9 | 150 | | | | |
| 1N3988 | S | MR1128 | 3-30 | R | 800 | 1.4 | 6 | .8 | 150 | | | | |
| 1N3989 | S | MR1130 | 3-30 | R | 900 | 1.4 | 6 | .7 | 150 | | | | |
| 1N3990 | S | MR1130 | 3-30 | R | 1000 | 1.4 | 6 | .6 | 150 | | | | |
| 1N3991 | G | | | GP | 35 | .55 | 30M | 1M | 1 | | | | |
| 1N3992 | S | | | HC | 4000 | 5 | 250M | 5• | | | | | |
| 1N3993 | S | | 2-24 | ZD | | | | | | | 3.9 | 10 | 10W |
| 1N3993A | S | | 2-24 | ZD | | | | | | | 3.9 | 5 | 10W |
| 1N3994 | S | | 2-24 | ZD | | | | | | | 4.3 | 10 | 10W |

← shaded AREA

shaded AREA →

R – Rectifier, RD – Reference Diode, ZD – Zener Diode, GP – General Purpose, HC – High Conductance (> 20 mA @ 1 V), HS – High Speed Switch (Max $t_{rr}$ < 0.3 µs), CS – High Conductance, High Speed Switch, MS – Medium Speed Switch, PA Parametric Amplifier, SP – Special Purpose.

*—— Silicon Rectifiers ——*

# 1N4001 thru 1N4007

**$I_O$ = 1 A**
**$V_R$ — to 1000 V**

**CASE 59**

Low-current, passivated silicon rectifiers in subminiature void-free, flame-proof silicone polymer case. Designed to operate under military environmental conditions.

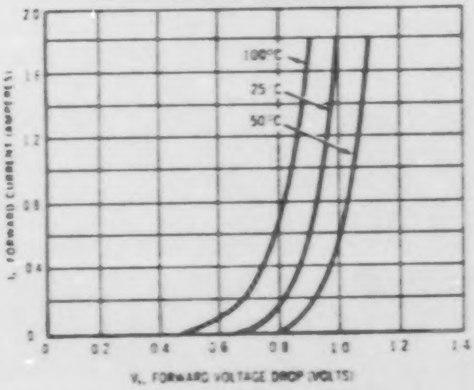
## MAXIMUM RATINGS (At 60 cps Sinusoidal, Input, Resistive or Inductive Load)

| Rating | Symbol | 1N4001 | 1N4002 | 1N4003 | 1N4004 | 1N4005 | 1N4006 | 1N4007 | Unit |
|---|---|---|---|---|---|---|---|---|---|
| Peak Repetitive Reverse Voltage<br>DC Blocking Voltage | $V_{RM(rep)}$<br>$V_R$ | 50 | 100 | 200 | 400 | 600 | 800 | 1000 | Volts |
| RMS Reverse Voltage | $V_r$ | 35 | 70 | 140 | 280 | 420 | 560 | 700 | Volts |
| Average Half-Wave Rectified Forward Current (75° C Ambient)<br>(100 C Ambient) | $I_O$ | 1000<br>750 | 1000<br>750 | 1000<br>750 | 1000<br>750 | 1000<br>750 | 1000<br>750 | 1000<br>750 | mA<br>mA |
| Peak Surge Current 25° C (1/2 Cycle Surge, 60 cps)<br>Peak Repetitive Forward Current | $I_{FM(surge)}$<br>$I_{FM(rep)}$ | 30<br>10 | 30<br>10 | 30<br>10 | 30<br>10 | 30<br>10 | 30<br>10 | 30<br>10 | Amps<br>Amps |
| Operating and Storage Temperature Range | $T_J, T_{stg}$ | -65 to + 175 | | | | | | | °C |

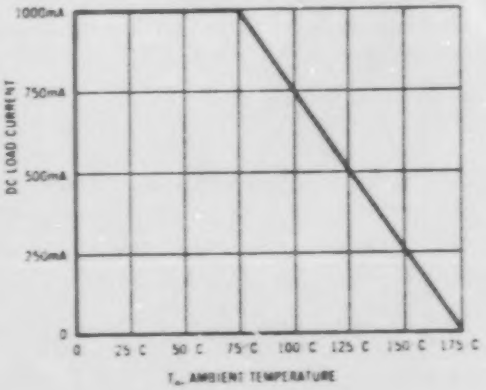
## ELECTRICAL CHARACTERISTICS

| Characteristic | Symbol | Rating | Unit |
|---|---|---|---|
| Maximum Forward Voltage Drop (1 Amp Continuous DC, 25°C) | $V_F$ | 1.1 | Volts |
| Maximum Full-Cycle Average Forward Voltage Drop (Rated Current @ 25°C) | $V_{F(AV)}$ | 0.8 | Volts |
| Maximum Reverse Current @ Rated DC Voltage (25°C)<br>(100°C) | $I_R$ | 0.01<br>0.05 | mA |
| Maximum Full-Cycle Average Reverse Current (Max Rated PIV and Current, as Half-Wave Rectifier, Resistive Load, 100 C) | $I_{R(AV)}$ | 0.03 | mA |

**TYPICAL FORWARD CHARACTERISTICS**



**MAXIMUM DC OUTPUT**



ET 110
Solid State
Study Guide Test #1
Chapters 1-4

Information Sheet #2

The listed statements are to act as a study guide for this examination. A thorough review of this document will significantly help in your preparation for this exam.

A listing of formulas will be allowed provided no definition of terms appears on the formula sheet. E = I x R is acceptable, volts = current x resistance is not acceptable. A calculators use is suggested for this test.

What devices are considered common semiconductor devices

The advantages of solid state devices

How temperature effects pure germanium

What holes in a semiconductor material represent

The movement of holes and electrons in pure semiconductor materials

The relationship of holes and electrons in a pure semiconductor

The type of semiconductor material most often used in solid state devices

The number of valence electrons in germanium/silicon

The characteristics of pure silicon at low temperaturaes

The composition of current flow in a semi-conductor

The number of electrons in a pentavalent material

The names of the materials used as pentavalent doping materials

The name of the dopent used to make silicon into an N type material

The minority and majority carriers in N type and in P type materials

The conductivities of doped semiconductor materials

The manner in which atoms are held together in pure semiconductor material

The reason semiconductor materials are doped

The charge relationship when atoms gain or lose electrons

The construction of a PN diode

The size of the depletion region in a PN diode

The silicon diode barrier voltage

The way to forward and reverse bias a PN diode

Calculate the current flow through a germanium diode given the battery voltage and series resistance

The characteristics of a reversed biased diode

The kind of carriers that support current in a reversed biased diode

The amount of leakage current in a silicon diode

The method used to measure a diode's reverse leakage current

The characteristics of a diode's breakdown voltage

The characteristics that change when a diode's temperature increases

The type of material a diode's anode and cathode are made of

The way to place a diode in a circuit that is forward biased.

The technique that is performed for the making of diodes

The technique that uses a gas to dope a diode

The way to bias a zener

What zener test current means

The way power dissipation in a zener can be decreased

Calculate the zener current knowing the zener voltage and power ratings

The temperature coefficient of a voltage reference diode

The temperature coefficient of a zenner when given the diodes operating voltage

The relationship of a zener's impedance to its curve shape

Load current vs zener current in a zener regulator circuit

Given the standard requirements, design a zener regulator circuit. Calculate the series resistance and the diode's power dissipation

The characteristic impedance of an ideal zener diode

Draw a regulated zener power supply given the standard components

The characteristics of a forward biased zener diode

The characteristics of a tunnel diode

The diode type that operates in it's negative resistance region

What diode type uses values of valley voltage

The characteristics of a varactor diode

The type of diode that varies the capacitance in a circuit

The type of diode in which Q is important

The characteristics of a hot carrier diode

The diode type that has an intrinsic region in the PN junction

The type of diode that does not have a true PN junction

Given the characteristic curves of four diode types, be able to identify the diode variety

ET 110
STUDY GUIDE
TEST #2

CHAPTERS 5, 6, 7 & TRANSISTOR BIASING

INFORMATION SHEET #3

The various names transistors are known by

The types of materials transistors are made of

The names given to the regions within the transistor

The name given to the center region within a transistor

The name given to a transistor that is composed with a center layer made out of P-type material.

Know the transistor symbols and what each lead signifies

The number of layers and junctions within a transistor

Name one of the transistor manufacturing processes

The application most transistors are used for

Properly bias the BE and BC junctions of linear, saturated and cutoff transistors

Know the relationship of $I_E$ to $I_B$ and $I_C$

The part of a transistor that dissipates the most heat

The E-B barrier potential of a silicon transistor

The majority carriers in PNP and NPN devices

The region within a transistor that is the largest

The percent base current is to emitter current

Be able to draw the three common transistor arrangements locating the batteries, load and signal source in the proper locations

The type of circuit that the input in 180° out of phase with the output

The circuit that provides power, current, and voltage amplification

The curcuit that has a high input and a low output impedance

The use of an ohmmeter to check a transistors condition

The dopping and thickness of transistor regions

The definition of alpha and to what type of base arrangement it applies

The typical range of transistor alphas

The percent given to the alpha cutoff frequency

What is $I_{CBO}$ and what effects its value

The most widely used transistor configuration

The definition of beta

Given a devices base, collector and emitter currents, calculate the devices alpha and beta

Given beta, calculate alpha

The relationahip of $I_{CBO}$ to $I_{CEO}$

What $V_{CBO}$ means

The type of substrate an N-channel JFET is constructed on

Where the gate is located in a JFET

What controls the JFET's depletion region size

Using a JFET characteristic curve, label the pinch-off region

The $V_{GS}$ characteristics of a enhancement and depletion mode MOSFET

The various names given to the MOSFET

The gate characteristic of a MOSFET

Given three FET and MOSFET characteristic curves, identify the types of devices associated with these curves

The N-channel JFET majority carriers

The current symbol for a JFET's drain

Draw, label and diagram P and N-channel JFETs

Bias a JFET

The region a JFET operates in

Given a voltage divider-emitter feedback bias BJT curcuit, calculate the values of each resistor, voltage drops and $I_C$ (sat)

Given the resistance values and other data, graph the load line and operating point (Q) for an emitter-collector bias BJT circuit

Be able to draw the waveforms for class A, AB, B, and C

ET 110
SOLID STATE
CHAPTERS 8 & 10
STUDY GUIDE

## INFORMATION SHEET #4

The names of the devices that are considered thyristors

The thyristor that is used the most often

A SCR has how many layers

Using two BJT's, draw the equivalent SCR circuit

The SCR leads are

The voltages/conditions necessary to turn on a SCR

How to turn off an SCR

What SCR forward conduction means

Properly bias a SCR circuit

The relationship of SCR forward breakover voltage to gate current

SCR gate current relationship to turn on time

What SCR's are used for

The purpose of a SCR's gate resistor

The AC alterations an SCR controls

The difference between an AC and DC SCR circuit

The name of a bidirectional thyristor

The physical construction of a triac

The type of device that can control both halves of an AC waveform

Identify the typical thyristro VI curves

The device that responds to positive and negative gate currents

An SCR triggering device is a

The semiconductor layers in a diac

Typical diac breakover voltage

Devices with negative resistances

The construction of a UJT

What UJT's are used for

Symbols for Triac, LED, Diac, UJT

What eta is

What controls a UJT's eta

The device Valley Voltage is associated with

Typical vales of eta

Typical UJT's waveforms

The differences in a PUT and UJT

The UJT lead names

The frequency of visible light in GH$_2$

The photosensitive device that is the slowest

Another name for the solar cell

Typical solar cell outputs-volts-amps

Solar cell efficiencies

Photosensitive device construction

A bidirectional photo device

The construction of a PIN photodiode and phototransistor

The purpose of a base lead in a phototransistor

How to bias a LED

What the notch means in a LED

The forward conducting LED voltage

The system light is measured in

What the photometric system measures

What light consists of

The resistive characteristics of the photoconductive cell

How a photovoltaic cell operates

The operating characteristics of phototransistors and photodiodes

How a LED produces light

The output characteristics of the LED vs the standard light bulb

Optical coupler consutrction

ET 110
Solid State
ZENER REGULATOR

Assignment #1
75 points

Name ______________________________

Using the information as presented in Chapter 3 of your text, design a regulated Zener power supply using the given information. In each problem determine the value of the series resistor, the maximum Zener power dissipation and the actual size (power rating) of the Zener chosen to insure an adequate power dissipation safety factor. See Page 2 for a catalog reprint listing available Zener power ratings and available Zener voltage ratings.

1. A 12-16 volt source is supplying a circuit requiring 9 volts. The load current varies between 200 and 350 mA.

2. A circuit requires a 35 volt regulated output with a load ranging from 1 to 1.5 amps. A 70-75 volt source is available to power the circuit.

3. Redesign the circuit in problem Number 2 to supply a load ranging from 10 mA to 1.15 amps. Under these conditions the input voltage varies from 70 to 80 volts.

4. A 400 volt regulated supply with a load ranging from 30 to 75 mA is being supplied by a 612 to 700 volt source.

5. A car provides 12 to 14.6 volts. A 6 volt radio with a load of zero to 210 mA needs to be utilized in the car.

# Zener Diodes

NOTE 10 watt and 50 watt Zeners listed have anode connected to stud. Add suffix letter "K" to the ECG number for cathode connected to stud. The ECG type numbers shown have a standard tolerance for the Zener voltage of ± 5%.

| Voltage | Axial Lead | | | Stud Mount | |
|---|---|---|---|---|---|
| | | | | DO-4 | DO-5 |
| (See Note for Tolerance) | Fig. No. Z5 | | Z21 | Z22 | Z23 |
| | **1/2 Watt** | **1 Watt** | **5 Watt** | **10 Watt** | **50 Watt** |
| 2.4 | ECG5000A | -- | -- | -- | -- |
| 2.5 | ECG5001A | -- | -- | -- | -- |
| 2.7 | ECG5002A | ECG5063A | -- | -- | -- |
| 2.8 | ECG5003A | -- | -- | -- | -- |
| 3.0 | ECG5004A | ECG5065A | -- | -- | -- |
| 3.3 | ECG5005A | ECG5066A | ECG5111A | ECG5172A | -- |
| 3.6 | ECG5006A | ECG134A | ECG5112A | ECG5173A | -- |
| 3.9 | ECG5007A | ECG5067A | ECG5113A | ECG5174A | ECG5240A |
| 4.3 | ECG5008A | ECG5068A | ECG5114A | ECG5175A | ECG5241A |
| 4.7 | ECG5009A | ECG5069A | ECG5115A | ECG5176A | ECG5242A |
| 5.1 | ECG5010A | ECG135A | ECG5116A | ECG5177A | ECG5243A |
| 5.6 | ECG5011A | ECG136A | ECG5117A | ECG5178A | ECG5244A |
| 6.0 | ECG5012A | ECG5070A | ECG5118A | ECG5179A | ECG5245A |
| 6.2 | ECG5013A | ECG137A | ECG5119A | ECG5180A | ECG5246A |
| 6.8 | ECG5014A | ECG5071A | ECG5120A | ECG5181A | ECG5247A |
| 7.5 | ECG5015A | ECG138A | ECG5121A | ECG5182A | ECG5248A |
| 8.2 | ECG5016A | ECG5072A | ECG5122A | ECG5183A | ECG5249A |
| 8.7 | ECG5017A | ECG5073A | ECG5123A | ECG5184A | ECG5250A |
| 9.1 | ECG5018A | ECG139A | ECG5124A | ECG5185A | ECG5251A |
| 10.0 | ECG5019A | ECG140A | ECG5125A | ECG5186A | ECG5252A |
| 11.0 | ECG5020A | ECG5074A | ECG5126A | ECG5187A | ECG5253A |
| 11.5 | -- | ECG141A | -- | -- | -- |
| 12.0 | ECG5021A | ECG142A | ECG5127A | ECG5188A | ECG5254A |
| 13.0 | ECG5022A | ECG143A | ECG5128A | ECG5189A | ECG5255A |
| 14.0 | ECG5023A | ECG144A | ECG5129A | ECG5190A | ECG5256A |
| 15.0 | ECG5024A | ECG145A | ECG5130A | ECG5191A | ECG5257A |
| 16.0 | ECG5025A | ECG5075A | ECG5131A | ECG5192A | ECG5258A |
| 17.0 | ECG5026A | ECG5076A | ECG5132A | ECG5193A | ECG5259A |
| 18.0 | ECG5027A | ECG5077A | ECG5133A | ECG5194A | ECG5260A |
| 19.0 | ECG5028A | ECG5078A | ECG5134A | ECG5195A | ECG5261A |
| 20.0 | ECG5029A | ECG5079A | ECG5135A | ECG5196A | ECG5262A |
| 22.0 | ECG5030A | ECG5080A | ECG5136A | ECG5197A | ECG5263A |
| 24.0 | ECG5031A | ECG5081A | ECG5137A | ECG5198A | ECG5264A |
| 25.0 | ECG5032A | ECG5082A | ECG5138A | ECG5199A | ECG5265A |
| 27.0 | ECG5033A | ECG146A | ECG5139A | ECG5200A | ECG5266A |
| 28.0 | ECG5034A | ECG5083A | ECG5140A | ECG5201A | ECG5267A |
| 30.0 | ECG5035A | ECG5084A | ECG5141A | ECG5202A | ECG5268A |
| 33.0 | ECG5036A | ECG147A | ECG5142A | ECG5203A | ECG5269A |
| 36.0 | ECG5037A | ECG5085A | ECG5143A | ECG5204A | ECG5270A |
| 39.0 | ECG5038A | ECG5086A | ECG5144A | ECG5205A | ECG5271A |
| 43.0 | ECG5039A | ECG5087A | ECG5145A | ECG5206A | ECG5272A |
| 45.0 | -- | -- | -- | ECG5207A | ECG5273A |
| 47.0 | ECG5040A | ECG5088A | ECG5146A | ECG5208A | ECG5274A |
| 50.0 | -- | -- | -- | ECG5209A | ECG5275A |
| 51.0 | ECG5041A | ECG5089A | ECG5147A | ECG5210A | ECG5276A |
| 52.0 | -- | -- | -- | ECG5211A | ECG5277A |
| 55.0 | -- | ECG148A | -- | -- | -- |
| 56.0 | ECG5042A | ECG5090A | ECG5148A | ECG5212A | ECG5278A |
| 60.0 | ECG5043A | ECG5091A | ECG5149A | ECG5213A | ECG5279A |
| 62.0 | ECG5044A | ECG149A | ECG5150A | ECG5214A | ECG5280A |
| 68.0 | ECG5045A | ECG5092A | ECG5151A | ECG5215A | ECG5281A |
| 75.0 | ECG5046A | ECG5093A | ECG5152A | ECG5216A | ECG5282A |
| 82.0 | ECG5047A | ECG150A | ECG5153A | ECG5217A | ECG5283A |
| 87.0 | ECG5048A | ECG5094A | ECG5154A | ECG5218A | -- |
| 91.0 | ECG5049A | ECG5095A | ECG5155A | ECG5219A | ECG5284A |
| 100.0 | ECG5050A | ECG5096A | ECG5156A | ECG5220A | ECG5285A |
| 105.0 | -- | -- | -- | ECG5221A | ECG5286A |
| 110.0 | ECG5051A | ECG151A | ECG5157A | ECG5222A | ECG5287A |
| 120.0 | ECG5052A | ECG5097A | ECG5158A | ECG5223A | ECG5288A |
| 130.0 | ECG5053A | ECG5098A | ECG5159A | ECG5224A | ECG5289A |
| 140.0 | ECG5054A | ECG5099A | ECG5160A | ECG5225A | ECG5290A |
| 150.0 | ECG5055A | ECG5100A | ECG5161A | ECG5226A | ECG5291A |
| 160.0 | ECG5056A | ECG5101A | ECG5162A | ECG5227A | ECG5292A |
| 170.0 | ECG5057A | ECG5102A | ECG5163A | ECG5228A | -- |
| 175.0 | -- | -- | - | ECG5229A | ECG5293A |
| 180.0 | ECG5058A | ECG5103A | ECG5164A | ECG5230A | ECG5294A |
| 190.0 | ECG5059A | ECG5104A | ECG5165A | ECG5231A | ECG5295A |
| 200.0 | ECG5060A | ECG5105A | ECG5166A | ECG5232A | ECG5296A |

Fig. Z5

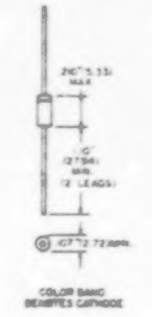


Fig. Z21

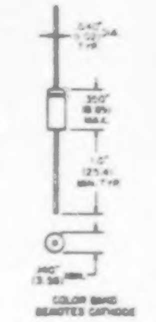


Fig. Z22

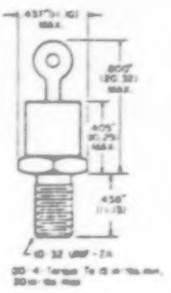
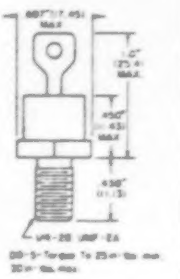


Fig. Z23



BEST COPY AVAILABLE

ET 110
Solid State
Test #1 Chapters 1-4

Test #1
74 points

Name________________________________

General Directions
This examination will be conducted from 5:20 pm to 7:20 pm. All papers must be turned in prior to 7:20 pm to reveive credit for this test. The use of a calculator is permitted along with a list of approved formulas. (Note: formulas may not contain definition of terms.) Read the specific directions for sections I & II as you reach those locations.

Section I multiple choice (44 points)
Circle only the letter representing your choice of the most correct response. Mark only one response per question.

1. The type of diode that is primary operated in its negative resistance region is the:

   a. zener diode
   b. hot carrier diode
   c. pin diode
   d. tunnel diode

2. In a pure semiconductor material electrons:

   a. move toward holes
   b. are attracted to the negative voltage source
   c. are attracted to the positive voltage source
   d. both A & C

3. A zener diode with a low impedence will have a zener breakdown region curve that will:

   a. have a gradual slope
   b. have a step slope
   c. be flat
   d. have a curve that can not be calculated

4. As the temperature of a diode increases the diodes:

   a. reverse current increases
   b. forward voltage drop decreases
   c. breakdown voltage increases
   d. all of the above

5. An N-type semiconductor is made by doping silicon with:

   a. arsenic
   b. phosphorous
   c. antimony
   d. any of the above

6. The hot carrier diode:

   a. has a barrier voltage that is one-half of a silicon diode
   b. is manufactured with a metal to semiconductor junction
   c. is used extensively in microwave mixers
   d. all of the above

7. One of the below is not an advantage of a solid-state component:

   a. small size
   b. require higher operating voltages
   c. more rugged
   d. operate with low voltages

8. The type of diode that must have a very high Q in order to work efficiently is the:

   a. tunnel diode
   b. varactor diode
   c. zener diode
   d. Gunn diode

9. A junction diode is made up of:

   a. two P junctions
   b. two N junctions
   c. one N junction
   d. one N and one P junction

10. A zener diode is basically manufactured to operate in its:

   a. forward biased region
   b. reversed biased region
   c. forward current region
   d. zener knee region

11. In a zener regulator circuit when the load current decreases, zener current will:

   a. stay the same
   b. decrease
   c. increase
   d. become negative

12. Semiconductor materials that are doped have conductivities that are:

   a. less than those in pure semiconductor materials
   b. greater than copper
   c. better than those in pure semiconductor materials
   d. equal to non-doped materials

13. An advantage of a solid state component is:

   a. savings in weight
   b. cost savings
   c. temperature sensitivity
   d. none of the above

14. The preferred technique of manufacturing diodes is:

    a. diffused junction technique
    b. alloyed junction technique
    c. grown junction technique
    d. seed crystal technique

15. When a diode is reversed biased it:

    a. conducts current in a forward direction
    b. limits electron flow
    c. has a very narrow depletion region
    d. has a large majority current flow

16. A semiconductor material has a conductivity that is:

    a. greater than a metal
    b. less than a metal
    c. equal to a metal
    d. none of the above

17. A forward biased zener diode has a voltage drop of:

    a. .3 volts
    b. .7 volts
    c. 1.6 volts
    d. the same as its zener voltage

18. To decrease the power dissipation in a zener diode one could:

    a. shorten the diode leads
    b. increase the value of the series resistor
    c. increase the load across the zener
    d. any of the above

19. The normal amount of leakage current in a silicon diode at room temperature is:

    a. greater than 1 amp
    b. greater than 1 mA
    c. less than 200 uA
    d. greater than 600 uA

20. Holes within a semiconductor will:

    a. repell electrons
    b. attract free electrons
    c. attract protons
    d. repell protons

21. To forward bias a diode the voltage source must be connected so that:

    a. the N material is connected to the positive side of the battery
    b. the P material is connected to the positive side of the battery
    c. the N material is connected to the negative side of the battery
    d. both B & C are required

22. The material most often used in today's solid state devices is:

    a. carbon
    b. silicon
    c. germanium
    d. coal

23. If a pure germanium crystal is heated to a very high temperature, it will act like a/an:

    a. insulator
    b. NPN junction
    c. semiconductor
    d. conductor

24. The depletion region in a standard PN diode extends:

    a. for only a short distance on each side of the junction
    b. throughout the entire semiconductor material
    c. on only the trivalent side
    d. on only the pentavalent side

25. The type of high frequency diode that has a pure semiconductor region placed between two heavily doped N and P sections is the:

    a. Gunn diode
    b. tunnel diode
    c. pin diode
    d. varactor diode

26. The zener test current is specified for which zener characteristic:

    a. rated zener voltage
    b. rated zener forward voltage
    c. minimum zener knee voltage
    d. zener reverse resistance

27. Atoms in a pure semiconductor material are held together:

    a. by their positive and negative charges
    b. by their covalent bonds
    c. in a random manner
    d. like atoms within a conductor

28. A voltage reference diode has a:

    a. negative temperature coefficient
    b. a large positive temperature coefficient
    c. a near zero temperature coefficient
    d. a slightly negative temperature coefficient

29. Which one of the below is not a commonly used semiconductor device:

    a. faraday filter
    b. diode
    c. transistor
    d. IC

30. A diode has ratings such as peak current, peak voltage, valley current and valley voltage. These ratings are characteristics of a:

    a. tunnel diode
    b. pin diode
    c. zener diode
    d. hot carrier diode

31. The main reason for doping a semiconductor material is to:

    a. make it physically stronger
    b. make it insensitive to temperature changes
    c. decrease its conductivity
    d. increase its conductivity

32. The flow of current in a semiconductor is made up of

    a. electrons
    b. holes
    c. electrons and holes
    d. free electrons

33. In order to measure a diodes reverse current characteristics, the diode must be biased with a:

    a. high voltage
    b. low voltage
    c. high current
    d. low current

34. A ten volt zener diode has a:

    a. negative temperature coefficient
    b. positive temperature coefficient
    c. zero temperature coefficient
    d. a slightly negative temperature coefficient

35. When a neutral atom takes on additional electrons, it has a charge that is now:

    a. negative
    b. positive
    c. neutral
    d. none of the above

36. In a semiconductor material holes represent:

    a. an excess of electrons
    b. free electrons
    c. an absence of electrons
    d. a proton

37. The reverse current of a standard PN diode suddenly increases when a certain value of voltage is applied. This point is known as the diodes:

    a. forward voltage drop
    b. cathode junction
    c. breakdown voltage
    d. forward current characteristic

38. The material that is not used as a pentavalent doping material is:

    a. gallium
    b. phosphorous
    c. arsenic
    d. antimony

39. The diode construction technique that uses a gas as the doping element to make the diode junctions is known as the:

    a. cathode method
    b. alloyed method
    c. grown method
    d. diffusion method

40. A tunnel diode has a:

    a. high internal barrier voltage
    b. lightly doped PN junction
    c. very narrow depletion region
    d. both A & C

41. At very low temperatures pure silicon crystals act like a/an:

    a. insulators
    b. conductors
    c. semiconductors
    d. PN junctions

42. The type of diode that does not have a PN junction is the:

    a. Gunn diode
    b. zener diode
    c. varactor diode
    d. none of the above

43. The ideal impedance of a zener would be:

    a. 0 ohms
    b. 10 ohms
    c. 400 ohms
    d. 10k ohms

44. A diode that is reversed biased will exhibit:

    a. low resistance
    b. an excess electron flow
    c. high resistance
    d. an excess hole flow

Section II Fill In (30 points)

Place the answer of your choice in the provided space.

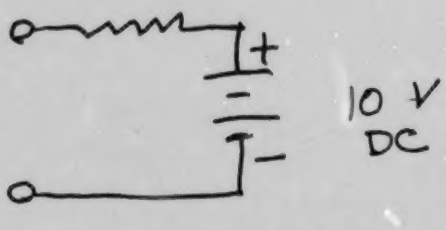
45. The number of electrons in the valence shell of silicon or germanium are

________________________.

46. The name given to the diode that is used to vary the capacitance in a circuit is a

________________________ diode.

47. Using the correct diode symbol, place a diode in the provided circuit so that the diode is forward biased.



48. In an N-type semiconductor material, the minority carriers are called

________________________.

49. You have an unregulated power supply. A zener diode. A load resistor and
50. a zener resistor. Draw a diagram of a regulated zener power supply using
51. the indicated components. Label input/outputs and voltage polarities on
52. the power supply and load. (4 points)

53. A germanium diode is forward biased with a 10 volt battery and current
54. limiting series resistor of 170 ohms. The current flow through this circuit is

________________________. (2 points)

55. A P-type semiconductor material has an excess of ________________________.

56. In a reversed biased diode leakage current is supported by ______________ carriers.

57. Find the maximum zener current for a 14 volt zener diode rated at 25 watts

________________________________.

58. Design a zener regulator with an output of 47 volts. Power supply inputs
59. range from 54 to 91 volts with output current requirements ranging from
60. 220mA to 4.7A. The series resistance is ____________________ and the
61. diode power dissipation is ______________________________. (4 points)

62. A pentavalent doping material is made up of ___________ valence electrons.

63. The barrier voltage in a silicon diode is ______________ volts.

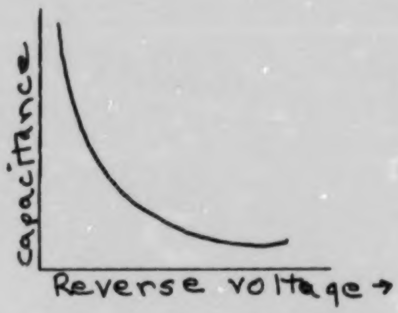
64. The cathode of a diode is made of __________ type material and the anode is made of ___________ type material. (Use N & P)

65. The minority carries in P-type semiconductor material are called

______________________________.

66. In N-type semiconductor materials there are an excess of ________________.

67. Identify the following characteristics diode curves. (8 points)
68.
69.
70.
71.
72.
73.
74.



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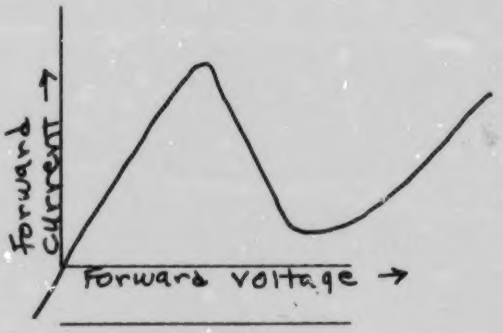

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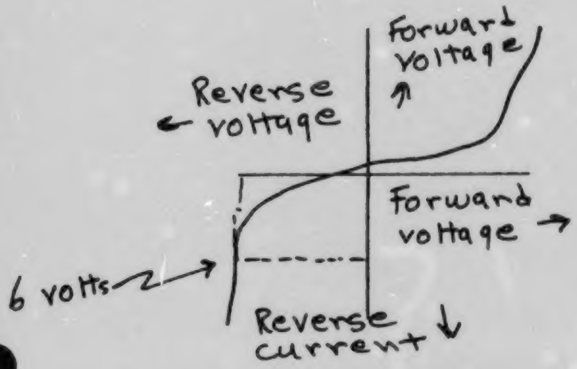

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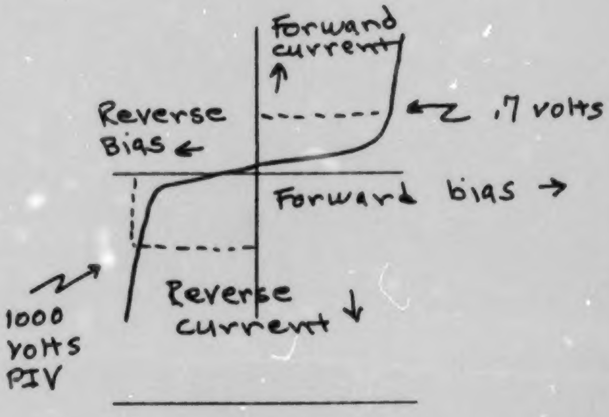

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ET 110
Solid State
Chapters 5-7 & Transistor Biasing

Test #2
97 Points

Name______________________________

General Directions
This examination will be conducted from 5:20 pm to 7:20 pm. All papers must be turned in prior to 7:20 pm to reveive credit for this test. The use of a calculator is permitted along with a list of approved formulas. (Note: formulas may not contain definition of terms.) Read the specific directions for sections I & II as you reach those locations.

Section I multiple choice (25 points)
Circle only the letter representing your choice of the most correct response. Mark only one response per question.

1. The three regions within a transistor have physically differing sizes. The region that is the largest is the:

   A. Emitter
   B. Base
   C. Collector
   D. They are all the same size

2. If the emitter current in a transistor increases the collector and base currents:

   A. Both decrease
   B. Collector increases, base decreases
   C. Base decreases only
   D. Both increase

3. $I_{CBO}$ will vary significantly with changes in:

   A. Reverse bias voltage
   B. Temperature
   C. Collector current
   D. Load current

4. A transistor that has a P-type material sandwiched between two layers of N-type material is known as a:

   A. Gate-source transistor
   B. NPN transistor
   C. Bipolar diode
   D. PNP transistor

5. In an NPN linearly biased transistor:

   A. $I_C = I_E + I_B$
   B. $I_E = I_B + I_C$
   C. $I_E = I_B - I_C$
   D. $I_C = I_E$

6. An ohmmeter is used to check a transistor. The reverse emitter base resistance reads 5 ohms. The transistor is:

    A. Shorted
    B. Open
    C. Normal
    D. Impossible to tell

7. Most of the heat dissipation in a transistor occurs:

    A. At the base
    B. At the collector
    C. At the emitter
    D. Evenly throughout the device

8. Transistors used in electronic equipment are basically used for:

    A. Switching
    B. Amplification
    C. Rectification
    D. Oscillators

9. The typical values of alpha for transistors range from:

    A. .1 to .5
    B. .95 to .995
    C. 1.9 to 2.7
    D. 100 to 250

10. The base current of a silicon PNP transistor is equal to what percent of the emitter current:

    A. .5%
    B. 1-5%
    C. 10-25%
    D. 95-99%

11. The transistor can be referred to as a:

    A. FET
    B. Bipolar transistor
    C. Junction transistor
    D. Either B or C

12. The substrate in a JFET is the devices:

    A. Source
    B. Drain
    C. Gate
    D. Base

13. The transistor circuit that provides current, voltage and power amplification is the:

    A. Common base
    B. Common emitter
    C. Common collector
    D. Emitter follower

14. A transistor has:

    A. Three layers and two junctions
    B. Two layers and two junctions
    C. Two layers and three junctions
    D. One layer and three junctions

15. $I_{CBO}$ refers to a transistors:

    A. Collector to base forward current
    B. Collector to base voltage
    C. Collector to base resistance
    D. Collector to base leakage current

16. A MOSFET has a gate that is:

    A. In contact with the substrate
    B. Insulated from the channel
    C. In contact with the channel
    D. Connected to the channel

17. The transistor circuit configuration that is the most widely used in the:

    A. Common base
    B. Common emitter
    C. Common collector
    D. Emitter follower

18. The size of the depletion region in a JFET is mostly controlled by:

    A. $V_{GS}$
    B. $I_D$
    C. $V_{DS}$
    D. $I_G$

19. A transistor is constructed from:

    A. Semiconductor material
    B. Germanium
    C. Silicon
    D. Any of the above

20. The transistor circuit that has a high input impedance, a low output impedance and a gain of one is the:

    A. Common base
    B. Common emitter
    C. Common collector
    D. Common source

21. The physical properties of a transistor's base region are:

    A. Thick base and lightly doped
    B. Thick base and heavy dopping
    C. Thin base and lightly doped
    D. Thin base and heavy dopping

22. The type of MOSFET that uses either a positive or negative gate voltage to control $I_D$ is the:

    A. Enhancement mode device
    B. P-channel FET
    C. Depletion mode device
    D. N-channel FET

23. A transistor is made of three regions. Its center region is called the:

    A. Base
    B. Source
    C. Emitter
    D. Collector

24. For any given transistor:

    A. $I_{CEO}$ $I_{CBO}$
    B. $I_{CEO}$ $I_{CBO}$
    C. $I_C$ $I_{CBO}$
    D. $I_E$ $I_{CEO}$

25. The type of MOSFET that does not conduct current when its $V_{GS}$ is:

    A. An enhancement mode device
    B. A depletion mode device
    C. A JFET
    D. N-channel FET

Section II Fill-in (72 points)

Place your answer in the provided space.

26. The beta of a transistor is 340. The transistors alpha is ______________.
27. (2 points)

28. Another name for an IGFET is the ______________________________________.

29. The name given to the transistor circuit arrangement in which the input is 180° out of phase with the output is the ______________________________.

30. The current gain of a common base transistor is known as the transistors ___________________________.

31. The symbol used to identify the current that flows through the channel of a JFET is __________________________.

32. An N-channel JFET is constructed on a substrate that is made out of _______________________ type material.

33. The current gain of a common emitter transistor is known as the transistor's ________________________.

34. The majority carriors in a N-channel JFET are ___________________________.

35. $V_{CBO}$ appears on a transistor specification sheet. Explain what is signi-
36. fies. (2 points)

37. The frequency at which the gain of a transistor drops to ________________% of its low frequency value is called the alpha cutoff frequency.

38. The majority carriors in a NPN transistor are _______________ and in a PNP
39. transistor are _______________. (2 points)

40. The JFET can only operate in the ______________________________ mode.

41. Transistors may be constructed (manufactured) using any number of processors. The name given to one of these processes or methods is:

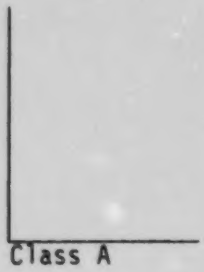
________________________________________________________________________.

42. Draw the diagram of a P-channel JFET.

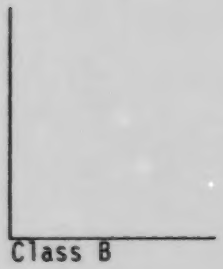
43. The internal barrier voltage developed across the emitter-base junction of a PNP silicon transistor is ____________________________________________.

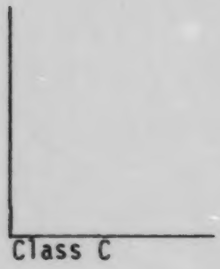
44. Draw the symbol for a PNP transistor and label each of the leads (2 points)
45.

46. Draw the waveforms for class A, AB, B, and C. (4 points)
47.
48.
49.


Class A

Class AB


Class B


Class C

50. Using the terms forward and reverse properly bias each of the junctions for
51. the indicated regions. (6 points)
52.
53. Linear
54.
55. Base - emitter ______________

Base - collector ______________

Saturated

Base-emitter ______________

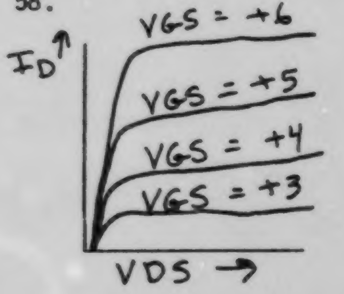
Base-collector ______________

Cut-off

Base-emitter ______________

Base-collector ______________

56. The three characteristic curves are all in reference to FETS and MOSFETS.
57. Label each set of curves as to the type of device it represents. (3 points)
58.



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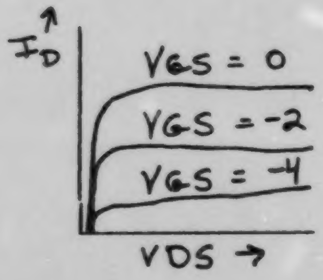

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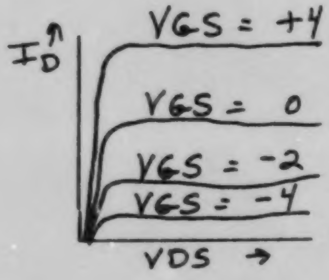

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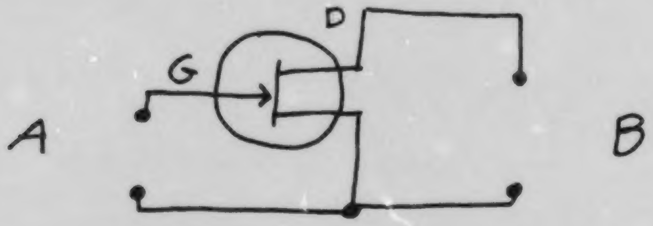
59. Properly bias the FET circuit by placing two batteries in position A & B.
60. Label each battery as to polarity. (2 points)



61. Using a linearly biased silicon NPN transistor, two batteries a load
62. resistor and a sine wave source draw each of the requested transistor cir-
63. cuit arrangements. (4 points each)
64.
65.
66.
67.
68.
69.
70.
71.
72.

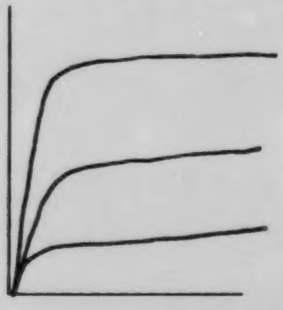
Common base

Common emitter

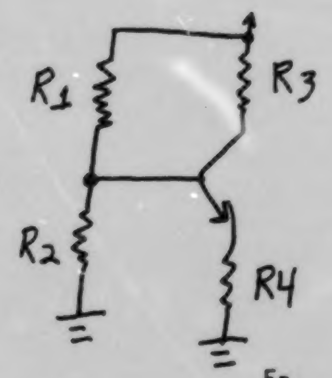
Common collector

73. A transistor base current is 10mA, collector current is 1 amp and emitter
74. current is 1010 mA. The devices alpha is ________________. The devices
75. beta is ___________________________. (4 points)
76.

77. Using the provided N-channel FET characteristic curve, label the area that is above pinch-off.



78. Calculate the values as requested. (14 points)
79.
80.
81.
82.
83.
84.
85.
86.
87.
88.
89.
90.
91.



$V_{CC}$ = 18V

$V_{CEQ}$ = 5V

$I_{CQ}$ = 3MA

$h_{FE}$ = 350

$V_{EQ}$ = 30%

Silicon device

$R_1$ __________

$R_2$ __________

$R_3$ __________

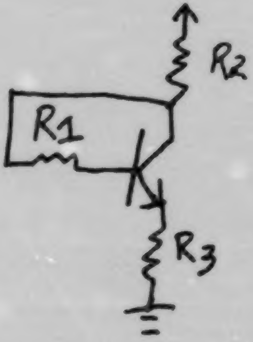
$R_4$ __________

$E_{R_4}$ __________

$E_{R_3}$ __________

$I_{C_{SAT}}$ = __________

92. Using the provided circuit graph the DC load line and plot the operating
93. point. (6 points)
94.
95.
96.
97.



$h_{FE}$ = 105
$V_{CC}$ = 30V
$R_1$ = 69.1k
$R_2$ = 3.642k
$R_3$ = 643 ohms
Silicon device

Extra Credit:

Using a PNP silicon transistor with an $h_{FE}$ of 100, a $V_{CC}$ of 12V, a $V_{CEQ}$ of - 6 volts and a $I_{CQ}$ of 1mA and using emitter feedback, calculate the requested data (8 points)

$V_{EQ}$ = __________

$R_C$ = __________

$R_E$ = __________

$R_B$ = __________

ET 110
Solid State
Chapters 8 & 10

Test #3
75 points

Name________________________________

## Section I Multiple Choice (25 points)

Circle only the letter representing your choice of the most correct response. Mark only one response per question.

1. A single SCR is able to control:

   a. both alterations of an AC input
   b. the positive alteration of an AC input
   c. the negative alteration of an AC input
   d. all of the above

2. When we compare the LED with an incandescent lamp we find that the LED has a:

   a. slower response and produces less light
   b. faster response and produces more light
   c. slower response but produces more light
   d. faster response but produces less light

3. The photovoltaic cell has an efficiency of:

   a. 1-2%
   b. 3-15%
   c. 16-25%
   d. 26-40%

4. The thyristor device that is used the most often is the:

   a. PUT
   b. UJT
   c. SCR
   d. BJT

5. The type of device that is a bidirectional device is the:

   a. LED
   b. photovoltaic cell
   c. photoconductive cell
   d. photodiode

6. A higher SCR gate current will effect the devices:

   a. reverse breakdown voltage
   b. intrinsic standoff ratio
   c. forward breakover voltage
   d. valley voltage

7. The LED emits light when the holes and electrons near its junction:

   a. separate
   b. recombine
   c. are forced to flow away from the junction
   d. are forced to flow toward the junction without recombining

8. A triac is effectively:

   a. two NPNP devices in parallel
   b. two PNPN devices in parallel
   c. one NPNP and one PNPN device in series
   d. one NPNP and one PNPN device in parallel

9. A single SCR AC circuit will allow:

   a. 0-25% control of the input AC power
   b. 0-50% control of the input AC power
   c. 50-100% control of the input AC power
   d. 0-100% control of the input AC power

10. A photo transistor consists of:

    a. NP junction
    b. PNP junction
    c. NPN junction
    d. PNPN junction

11. Valley voltage is associated with:

    a. BJT
    b. triac
    c. UJT
    d. diac

12. When comparing photodiodes and phototransistors we find that phototransistors have a:

    a. higher output current and a faster response
    b. lower output current and a faster response
    c. higher output current and a slower response
    d. lower output current and a slower response

13. UJT's are used in circuits requiring:

    a. amplifying
    b. linear oscillations
    c. on/off switching
    d. none of the above

14. The flat or notched side of an LED indicates the devices:

    a. emitter lead
    b. cathode lead
    c. gate lead
    d. anode lead

15. When comparing the DC SCR circuit with an AC SCR circuit the:

    a. AC circuit is more complicated
    b. DC circuit is more complicated
    c. the AC circuit requires one less SCR for operation
    d. the AC circuit requires two SCR's for operation

16. The number of semiconductor layers n a SCR are:

    a. 2
    b. 3
    c. 4
    d. 5

17. The photovoltaic cell responds to changes in light intensity by:

    a. varying its transconductance
    b. changing its conductivity
    c. changing its resistance
    d. generating an output voltage

18. The type of device that has the slowest response of all light sensitive devices is the:

    a. LED
    b. photodiode
    c. photoconductive cell
    d. photovoltaic cell

19. In order to turn on an SCR the gate current is:

    a. applied for only an instant
    b. the gate current is a positive value
    c. applied as a current pulse
    d. all of the above

20. Another name given to a bidirectional trigger diode is the:

    a. UJT
    b. SCR
    c. diac
    d. triac

21. Light is thought to consist of many tiny particles or bundles of energy called:

    a. neutrons
    b. cosmic particles
    c. protons
    d. photons

22. The name given to the lead attached to the UJT's P-type pellet is:

    a. emitter
    b. base
    c. collector
    d. gate

23. The type of device that exhibits negative resistance characteristic is/are:

    a. diac
    b. SCR
    c. UJT
    d. both A & C

24. The device that is bidirectional is:

    a. triac
    b. SCR
    c. UJT
    d. diode

25. The photometric system is used to measure:

    a. visible light only
    b. infrared light only
    c. both visible and infrared light
    d. the entire light spectrum

26. The device that is not a thyristor is:

    a. PUT
    b. UJT
    c. SCR
    d. FET

27. The lead most often not used in a phototransistor is the:

    a. emitter
    b. base
    c. collector
    d. all 3 leads must be used for circuit operation

28. The name of the triggering device used to turn on a triac is a:

    a. UJT
    b. SCR
    c. diac
    d. none of the above

29. The names given to the three leads attached to an SCR are:

    a. anode, gate, cathode
    b. emitter, gate, cathode
    c. cathode, base, anode
    d. anode, drain, cathode

30. A UJT when compared to a PUT:

    a. is more sensitive than a PUT
    b. responds faster than a PUT
    c. can supply higher amplitude pulses
    d. none of the above

31. When an LED and phototransistor are mounted in the same package, and connected by a light beam which can transmit electrical signals, the device formed is known as:

    a. an optical coupler
    b. an optical limit switch
    c. a photo-darlington circuit
    d. an LED display

32 . In an SCR, as the gate current decreases the devices:

    a. reverse breakdown voltage remains the same
    b. intrinsic stand off ratio goes negative
    c. valley voltage decreases
    d. forward breakover voltage increases

33. A diac is composed of:

    a. PNP layers
    b. NPNP layers
    c. NPN layers
    d. PNPN layers

34. The resistance of a photoconductive cell will be extremely high when:

    a. it is exposed to a high intensity light
    b. no light strikes its surface
    c. it is reverse-biased
    d. it is forward biased

35. A UJT is composed of:

    a. PN junction
    b. NPN junction
    c. PNP junction
    d. NPNP junction

36. The SCR is primarily used for:

    a. linear amplification
    b. a relaxation oscillator
    c. supplying trigger pulses
    d. controlling AC & DC power loads

37. The type of device that does not have a PN junction is the:

    a. LED
    b. photovoltiac cell
    c. photoconductive cell
    d. photodiode

38. A typical diac breakdown voltage is:

    a. 5-15 volts
    b. 10-20 volts
    c. 23-36 volts
    d. 70-140 volts

39. Light is commonly measured by the:

    a. photometric system
    b. radiometric system
    c. both the radiometric and photometric systems
    d. isometric system

40. A UJT's eta can be controlled by:

    a. the physical construction of the device
    b. the value of $V_{BB}$
    c. the value of $V_S$
    d. none of the above

41. The device that can control AC currents flowing in either direction is the:

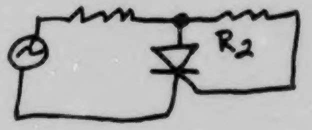
    a. PUT
    b. FET
    c. BJT
    d. none of the above

SECTION II FILL IN (34 points)

Place your answer in the space provided.

42. The type of photo diode that has an intrinsic layer between its regions is known as a _______________ diode.

43. The purpose of $R_2$ is:



44. Draw the symbols for the following devices. (4 points)
45.
46.
47.

UJT

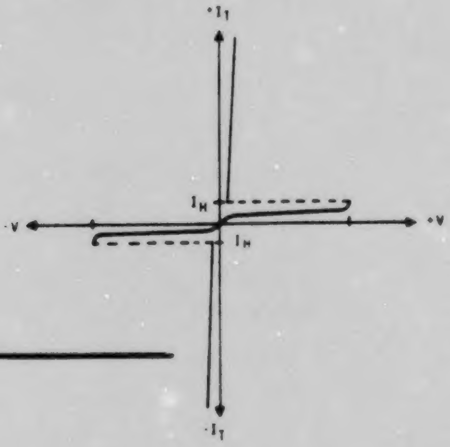
Triac

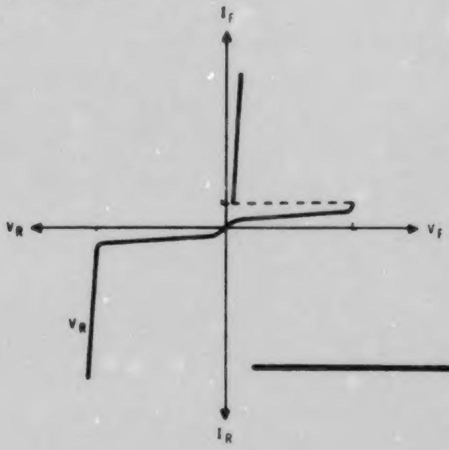
Diac

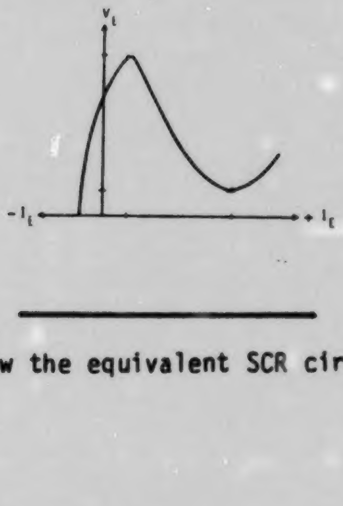
LED

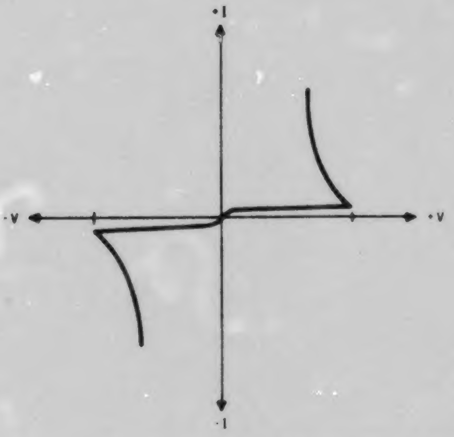
48. A SCR that is on is conducting in the ______________ direction.
forward - reverse

49. Identify the device VI characteristic curve (4 points).
50.
51.
52.









53. Draw the equivalent SCR circuit using two BJT transistors (2 points).
54.

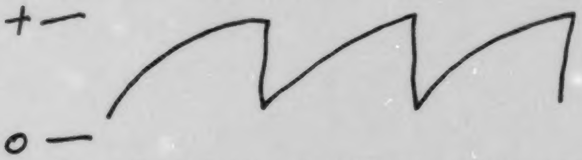
55. In a UJT the Greek letter eta is used to represent the devices.

_______________________________________________

56. The name of the device that will respond to either a negative or positive gate current is the ______________________________.

57. The typical output from a single solar at 2000 footcandles illumination is
58. ____________ volts at ____________mA. (2 points)

59. Name the type of active device that is used to generate this waveform.

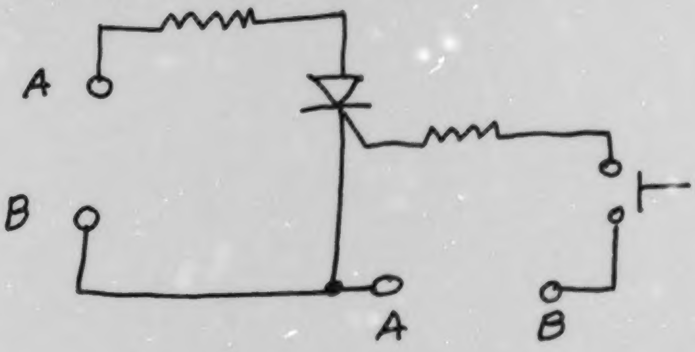


____________________

60. In order to turn an SCR on, it is necessary to place a ______________
61. voltage on the _______ with respect to the cathode. positive - negative

62. The voltage across a conducting LED is typically ______________ volts.

63. Properly bias the SCR circuit by placing a pair of batteries at points A &
64. B. Indicate battery polarity. (2 points)



65. The common name for a photovoltaic cell is ____________________.

66. In order to produce light a LED must be ______________ biased.
forward - reverse

67. The primary voltage control difference between a PUT and a UJT is:
68. (2 points)

69. There are two conditions that must be met in order for an SCR to turn on.
70. These two conditions are: (2 points)

a. ______________________________________________

b. ______________________________________________

71. An SCR operating in a DC circuit is in its conducting state. Describe a
72. procedure that could be used to turn the SCR off without damaging the device. (2 points)

73. The UJT's eta is typically ____________ volts.

74. The frequency in GHz of the visible light region is from _________ GHz to
75. _________ GHz. (2 points)

ET 110
Solid State
Diode Characteristics

Lab #1 Name(s)________________________

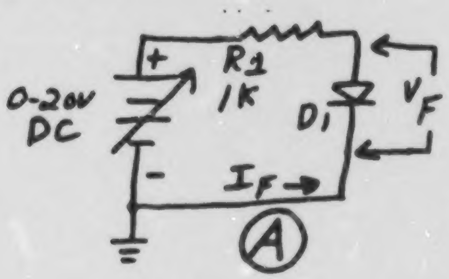
30 Points ________________________

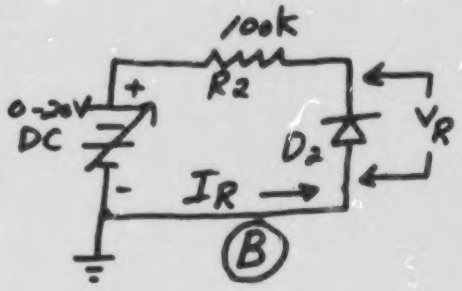
**Objective:** To determine the characteristics of a germanium and a silicon diode.

**Materials:** Silicon diode, germanium diode, 1k ohm and 100k ohm, resistors, graph paper.

**Equipment:** Power supply, DMM, Proto board.

**Circuits:**





**Procedure:** Measure and record the exact values of $R_1$ and $R_2$. These values will be used to calculate the current flow through $D_1$ and $D_2$. Construct circuit A. Adjust the power supply to provide a forward ($I_F$) diode current of .1mA. Use the value of $R_1$, the voltage drop across $R_1$ and Ohm's Law to determine the proper voltage across $R_1$ for a current flow of .1mA. Record this voltage value in the provided chart.

Measure the forward voltage drop ($V_F$) across $D_1$ and record. Record all values indicated in the chart for both the germanium and silicon diodes.

12 points

| $I_F$ in mA | .1 | .2 | .3 | .4 | .5 | .6 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $E_{R_1}$ | | | | | | | | | | | | |
| $V_F$ Germanium | | | | | | | | | | | | |
| $V_F$ Silicon | | | | | | | | | | | | |

10 points Using ten squares to the inch graph paper, plot $I_F$ in mA in the vertical axis and $V_F$ in the horizontal axis. Graph both the germanium and silicon diode characteristic curves.

Construct circuit B to measure the diodes reverse current characteristics. Apply the indicated voltages, (record $E_{R_2}$ and $V_{R_2}$) and then calculate the required diode reverse current ($I_R$).

8 points

| $V_R$ in Volts | 5 | 10 | 15 | 20 | 30* | 40* |
|---|---|---|---|---|---|---|
| $I_R$ mA Germanium | | | | | | |
| $I_R$ mA Silicon | | | | | | |

* Dangerous voltages - use caution

ET 110
Solid State
PRACTICAL DIODE TESTS

Lab #2
78 points

Name(s)________________

________________

**OBJECTIVE:** To determine whether a diode is germanium or silicon.

**MATERIALS:** One red, one black and one gray diode, 1k 4.75 ohm and 100K ohm resistors

**EQUIPMENT:** Power Supply, Proto-board, VOM and DMM

**PROCEDURE:** Determine the forward and reverse diode resistances and ratios by measuring with a VOM. The red lead is positive on the Simpson VOM's.

Forward and reverse bias each diode with the VOM and record the data. Indicate the meter multiplier used with the VOM. Calculate the ratio by dividing the reverse resistance by the forward resistance.

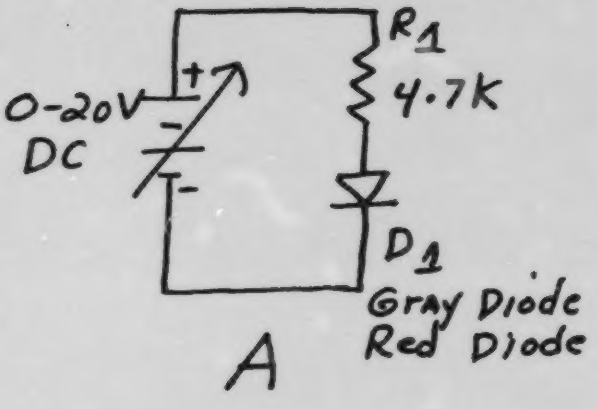
| Diode | $R_F$ | Mult | $R_R$ | Mult | $R_R/R_F$ | Type |
|---|---|---|---|---|---|---|
| Red | | | | | | |
| Gray | | | | | | |
| Black | | | | | | |

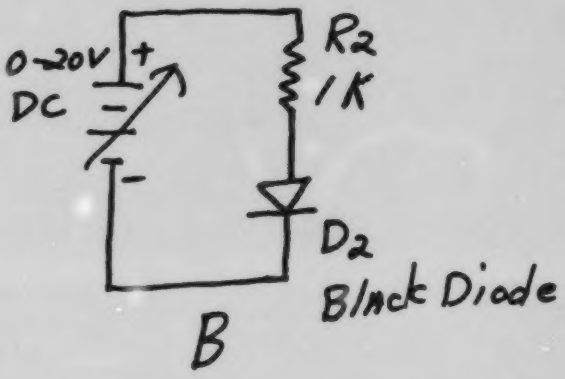
18 points

Determine the diode type by observing the ratio of reverse vs forward resistances. Refer to the text to determine what ratios are applicable to various diode types. Indicate your choice of silicon or germanium in the above "Type" column. State your reasons for your choice.

10 points

CIRCUIT:





PROCEDURE: Construct circuit "A" and adjust the power supply for a circuit current of 1 mA. Measure the current indirectly by using the resistor value and its circuit voltage drop. Measure the drop across each component and record.

| Diode | $R_1$ | $E_{R1}$ | $E_{D1}$ | $I_{R1}$ | Type |
|---|---|---|---|---|---|
| Red | | | | | |
| Gray | | | | | |

9 points

10 points

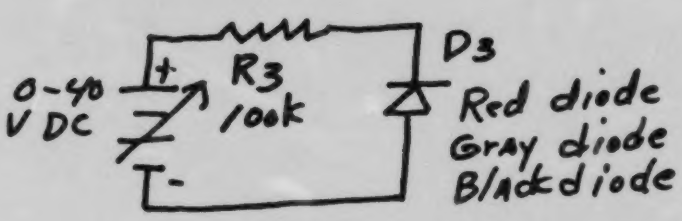
Determine which of the diodes are silicon or germanium and your reasons for that choice.

Construct circuit "B" and adjust the power supply for a circuit current of 10 mA. Measure the requested data and record.

| Diode | $R_2$ | $E_{R2}$ | $E_{D2}$ | $I_{R2}$ | Type |
|---|---|---|---|---|---|
| Black | | | | | |

5 points

CIRCUIT:



PROCEDURE: Measure the reverse leakage current of the three diodes and record below using the 100K ohm resistor and circuit "C" at 10, 20, 30, and 40 volts.

| Diode | $R_3$ | I@10V | I@20V | I@30V | I@40V | Type |
|---|---|---|---|---|---|---|
| Red | | | | | | |
| Gray | | | | | | |
| Black | | | | | | |

16 points

10 points

Using the data in the text, determine the diode type and your reasons for those choices.

ET 110
Solid State
ZENER REGULATOR

Lab #3
125 points

Name ______________________

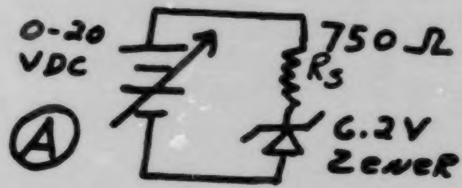
______________________

**OBJECTIVE:** To evaluate the characteristics of a Zener diode both in a test circuit and in a properly designed regulator circuit.

**MATERIALS:** 6.2 volt Zener, 750 ohm resistor, and various other values of load resistors

**EQUIPMENT:** Power supply, proto-board, DMM

**CIRCUIT:**



**PROCEDURE:** Construct circuit "A". Measure the applied voltage and the voltages across the series dropping resistor and Zener diode at the specified total circuit currents. Record in the provided chart.

|  | $E_{RS}$ | $E_Z$ | $E_{supply}$ |
|---|---|---|---|
| 100uA |  |  |  |
| 500uA |  |  |  |
| 1mA |  |  |  |
| 5mA |  |  |  |
| 8mA |  |  |  |
| 10mA |  |  |  |
| 15mA |  |  |  |

21 points

**PROCECURE:** Using circuit "A" apply a reverse bias voltage sufficient to obtain a measured Zener voltage of 6.2 volts. Record the below requested data indicating the voltages across all components and the Zener current value.

| $E_Z$ | $I_Z$ | $E_{RS}$ | $E_{supply}$ | $R_S$ |
|---|---|---|---|---|
|  |  |  |  |  |

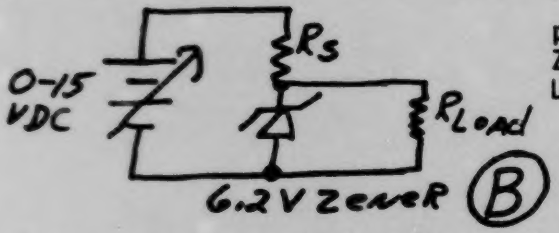
5 points

PROCEDURE: Using circuit "A" forward bias the diode using the necessary supply voltage to obtain a total circuit current of 10mA. Measure the voltage drop across each component along with the total circuit current.

| $E_Z$ | $I_Z$ | $E_{RS}$ | $E_{supply}$ |
|---|---|---|---|
|  |  |  |  |

4 points

CIRCUIT:



power supply 12-15 VDC
Zener 6.2VDC @ 500mW
Load 10-35mA

PROCEDURE: Design a Zener regulater power supply. Calculate the values of all necessary components including the power dissipation under worst case conditions for each component. Place your calculated values in the below chart. SHOW ALL CALCULATIONS used to arrive at your answers.

| $R_S$ | $P_{RS}$ | $P_Z$ |
|---|---|---|
|  |  |  |

3 points

PROCEDURE: Construct circuit "B" using the values calculated, making sure $R_S$ has sufficient power handling capacity to dissipate the heat generated during the tests. Apply 12VDC to the circuit input and measure the requested circuit parameters under the various load conditions. Calculate the necessary value of the load resistor assuming a 6.2 volt regulated output.

| Circuit Load | $R_{load}$ | $I_Z$ *2 | $I_{total}$ *1 | $E_Z$ | $E_{load}$ | $E_{RS}$ | $I_{load}$ |
|---|---|---|---|---|---|---|---|
| 0mA |  |  |  |  |  |  |  |
| 10mA |  |  |  |  |  |  |  |
| 20mA |  |  |  |  |  |  |  |
| 35mA |  |  |  |  |  |  |  |
| 50mA |  |  |  |  |  |  |  |
| 75mA |  |  |  |  |  |  |  |

21 points

*1 Determined by measuring the resistance value of $R_S$ and the voltage across $R_S$.

*2 Obtained by subtracting the load current from the total current.

PROCEDURE: Repeat the above procedure again using circuit "B" with your calculated values. However, apply 15VDC to the circuit input and measure the resultant circuit parameters.

| Circuit Load | $R_{load}$ | $I_Z$ | $I_{total}$ | $E_Z$ | $E_{load}$ | $E_{RS}$ | $I_{load}$ |
|---|---|---|---|---|---|---|---|
| 0mA | | | | | | | |
| 10mA | | | | | | | |
| 20mA | | | | | | | |
| 35mA | | | | | | | |
| 50mA | | | | | | | |
| 75mA | | | | | | | |

21 points

At what load current value did the above circuit fail to regulate? Is this point the same for both circuits? In the above two questions state your reasons for justification of your answers.

15 points

PROCEDURE: Measure the Zener voltage at a load current of 20mA in circuit "B" at 15VDC. Use this value as the nominal voltage for the following calculations.

Remove the load from circuit "B". Decrease the power supply voltage until the measured Zener voltage drops 1 volt from the nominal voltage. This will be considered the point at which loss of regulation occurs. Record the following in the first data line.

| $E_{supply}$ | $I_{load}$ | $I_{total}$ | $E_Z$ | $E_{load}$ | $E_{RS}$ | $E_z$ at 15 V |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |

16 points

PROCEDURE: Place a 35mA load in circuit "B" with a supply input of 15VDC. Again, as in the above, decrease the power supply voltage to achieve a 1 volt loss of regulation. Record in the second data line on page three.

14 points Which circuit lost regulation first. Why? (Analyze by looking at current values).

ET 110
Solid State
TRANSISTOR LEAD IDENTIFICATION

Lab #4
100 points

Name(s)________________________

________________________

OBJECTIVE: 1. To identify the pin-outs on unidentified bipolar transistors.
2. To determine whether a transistor is a NPN or a PNP device.

MATERIALS: One each of the following: 2N2614, 2N3391, 2N4106, 2N2894, 2N3055, 2N3740, 2N4105, and 2N4124

EQUIPMENT: Simpson VOM

PROCEDURE: Use a VOM to forward and reverse bias each transistor junction as indicated in the provided charts. The Simpson VOM simplifies the task as the black lead supplies an excess of electrons (negative lead) with the red lead being the positive lead. Using this information, forward and reverse bias each junction as indicated recording the junction resistance of each pair. It will be necessary to change the resistance range position switch, as forward and reverse resistances vary widely.

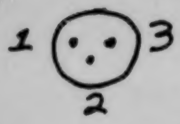
After making a junction resistance measurement place a check in either the forward or reverse bias column. If necessary, review the material in the text concerning transistor and/or diode biasing.

Once the chart is finished two tasks must be completed. First, determine the transistor pin-outs and list them in the provided space by placing a check mark in the columns. Second, determine the type of transistor (NPN or PNP) and place a check mark in the correct column.

PROCEDURE: Complete this part after the charts are finished. Describe the methods and rationale you used to determine which leads were the emitter, collector and base.
10 points

PROCEDURE: Complete this part after the charts are finished. Describe the methods and reasons you used to determine whether the device was a PNP or a NPN transistor.

Transistor: 2N2614



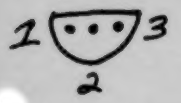
| Red | Black | Resistance | Bias | |
|---|---|---|---|---|
| | | | For | Rev |
| 1 | 2 | | | |
| 2 | 1 | | | |
| 2 | 3 | | | |
| 3 | 2 | | | |
| 1 | 3 | | | |
| 3 | 1 | | | |

| Pin-Out | E | B | C |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

| | NPN | PNP |
|---|---|---|
| Device Type | | |

10 points

Transistor: 2N3391



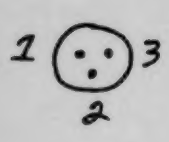
| Red | Black | Resistance | Bias | |
|---|---|---|---|---|
| | | | For | Rev |
| 1 | 2 | | | |
| 2 | 1 | | | |
| 2 | 3 | | | |
| 3 | 2 | | | |
| 1 | 3 | | | |
| 3 | 1 | | | |

| Pin-Out | E | B | C |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

| | NPN | PNP |
|---|---|---|
| Device Type | | |

10 points

Transistor: 2N4106



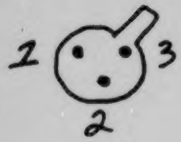
| Red | Black | Resistance | Bias | |
|---|---|---|---|---|
| | | | For | Rev |
| 1 | 2 | | | |
| 2 | 1 | | | |
| 2 | 3 | | | |
| 3 | 2 | | | |
| 1 | 3 | | | |
| 3 | 1 | | | |

| Pin-Out | E | B | C |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

| | NPN | PNP |
|---|---|---|
| Device Type | | |

10 points

Transistor: 2N2894



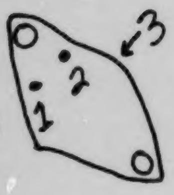
| | | | Bias | |
|---|---|---|---|---|
| Red | Black | Resistance | For | Rev |
| 1 | 2 | | | |
| 2 | 1 | | | |
| 2 | 3 | | | |
| 3 | 2 | | | |
| 1 | 3 | | | |
| 3 | 1 | | | |

| Pin-Out | E | B | C |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

| | NPN | PNP |
|---|---|---|
| Device Type | | |

10 points

Transistor: 2N3055



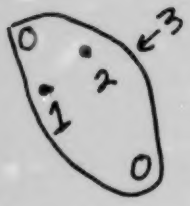
| | | | Bias | |
|---|---|---|---|---|
| Red | Black | Resistance | For | Rev |
| 1 | 2 | | | |
| 2 | 1 | | | |
| 2 | 3 | | | |
| 3 | 2 | | | |
| 1 | 3 | | | |
| 3 | 1 | | | |

| Pin-Out | E | B | C |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

| | NPN | PNP |
|---|---|---|
| Device Type | | |

10 points

Transistor: 2N3740



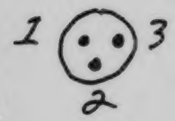
| | | | Bias | |
|---|---|---|---|---|
| Red | Black | Resistance | For | Rev |
| 1 | 2 | | | |
| 2 | 1 | | | |
| 2 | 3 | | | |
| 3 | 2 | | | |
| 1 | 3 | | | |
| 3 | 1 | | | |

| Pin-Out | E | B | C |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

| | NPN | PNP |
|---|---|---|
| Device Type | | |

10 points

Transistor: 2N4105



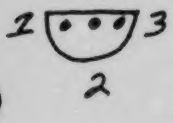
| Red | Black | Resistance | Bias | |
|---|---|---|---|---|
| | | | For | Rev |
| 1 | 2 | | | |
| 2 | 1 | | | |
| 2 | 3 | | | |
| 3 | 2 | | | |
| 1 | 3 | | | |
| 3 | 1 | | | |

| Pin-Out | E | B | C |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

| | NPN | PNP |
|---|---|---|
| Device Type | | |

10 points

Transistor: 2N4124



| Red | Black | Resistance | Bias | |
|---|---|---|---|---|
| | | | For | Rev |
| 1 | 2 | | | |
| 2 | 1 | | | |
| 2 | 3 | | | |
| 3 | 2 | | | |
| 1 | 3 | | | |
| 3 | 1 | | | |

| Pin-Out | E | B | C |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

| | NPN | PNP |
|---|---|---|
| Device Type | | |

10 points

ET 110
Solid State
COMMON EMITTER TRANSISTOR

Lab #5
78 points

Name(s) ______________________

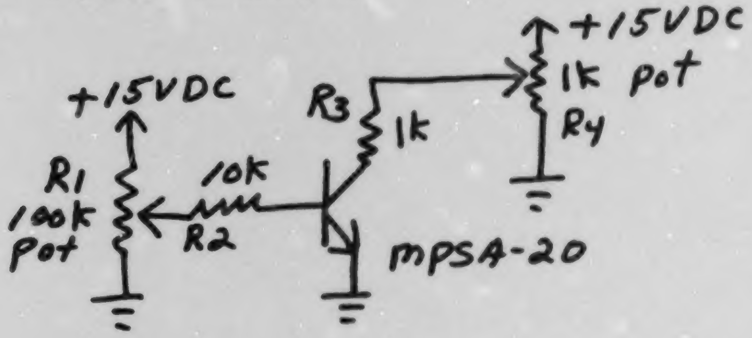
______________________

**OBJECTIVE:** To verify by experiment the characteristics of a transistor connected in a common emitter circuit.

**MATERIALS:** MPSA-20 NPN transistor (417-801), 1k ohm and 10k ohm resistors, 100k ohm pot and 1k ohm pot, graph paper

**EQUIPMENT:** Power supply, Proto-board, DMM

**CIRCUIT:**



**PROCEDURE:** Construct the common emitter transistor circuit using a pot for $R_1$ and $R_4$. Adjust $R_4$ for 500 ohms (mid-range). Then adjust $R_1$ for a base current of 10uA as measured through $R_2$. Use the indirect method of measuring current. Record the value of $R_2$ and the voltage drop across $R_2$ in the space provided.

2 points

| | Value in ohms | Volts |
|---|---|---|
| $R_2$ | | |

Adjust $R_4$ for a $V_{CE}$ of 1 volt. Do not readjust $R_1$ as base current must remain at 10uA. Adjust $R_4$ for each of the required $V_{CE}$ values as listed in the provided table. Measure $I_C$ by using the indirect method. Record $E_{R3}$ and calculate $I_{CE}$.

12 points

| | Base Current $I_B$ = 10uA | | | | | |
|---|---|---|---|---|---|---|
| $V_{CE}$ Volts | 1 | 2 | 3 | 4 | 5 | 6 |
| $E_{R3}$ Volts | | | | | | |
| $I_{CE}$ mA | | | | | | |

ET 110
Solid State
# COMMON EMITTER TRANSISTOR

Lab #5
78 points

Name(s) ____________________

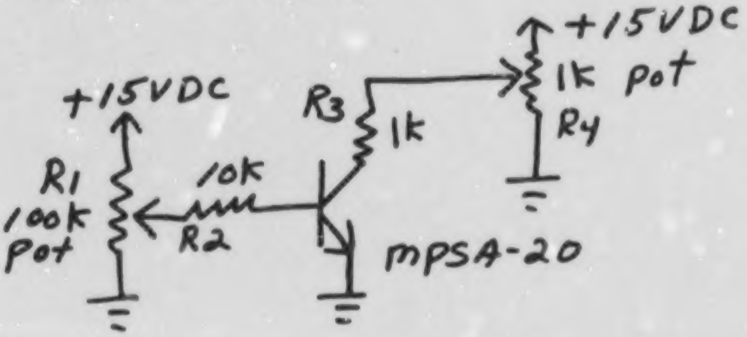
____________________

OBJECTIVE: To verify by experiment the characteristics of a transistor connected in a common emitter circuit.

MATERIALS: MPSA-20 NPN transistor (417-801), 1k ohm and 10k ohm resistors, 100k ohm pot and 1k ohm pot, graph paper

EQUIPMENT: Power supply, Proto-board, DMM

CIRCUIT:



PROCEDURE: Construct the common emitter transistor circuit using a pot for $R_1$ and $R_4$. Adjust $R_4$ for 500 ohms (mid-range). Then adjust $R_1$ for a base current of 10uA as measured through $R_2$. Use the indirect method of measuring current. Record the value of $R_2$ and the voltage drop across $R_2$ in the space provided.

2 points

| | Value in ohms | Volts |
|---|---|---|
| $R_2$ | | |

Adjust $R_4$ for a $V_{CE}$ of 1 volt. Do not readjust $R_1$ as base current must remain at 10uA. Adjust $R_4$ for each of the required $V_{CE}$ values as listed in the provided table. Measure $I_C$ by using the indirect method. Record $E_{R3}$ and calculate $I_{CE}$.

12 points

| | Base Current $I_B$ = 10uA | | | | | |
|---|---|---|---|---|---|---|
| $V_{CE}$ Volts | 1 | 2 | 3 | 4 | 5 | 6 |
| $E_{R3}$ Volts | | | | | | |
| $I_{CE}$ mA | | | | | | |

PROCEDURE: Readjust $R_1$ for a base current of 20uA and complete the table as was done in the previous example.

| | Base Current $I_B$ = 20uA | | | | | |
|---|---|---|---|---|---|---|
| $V_{CE}$ Volts | 1 | 2 | 3 | 4 | 5 | 6 |
| $E_{R3}$ Volts | | | | | | |
| $I_{CE}$ mA | | | | | | |

12 points

PROCEDURE: Readjust $R_1$ for a base current of 30uA and complete the table.

| | Base Current $I_B$ = 30uA | | | | | |
|---|---|---|---|---|---|---|
| $V_{CE}$ Volts | 1 | 2 | 3 | 4 | 5 | 6 |
| $E_{R3}$ Volts | | | | | | |
| $I_{CE}$ mA | | | | | | |

12 points

PROCEDURE: Starting in the lower left hand corner of the provided graph paper, lable the vertical axis at one inch intervals in 1mA steps ($I_C$). Likewise, lable the horizontal axis at one inch intervals in one volt steps ($V_{CE}$). Plot three curves, one for each of the three base current standards. Plot $V_{CE}$ in relation to $I_{CE}$. Lable each curve as to transistor base current.

20 points

PROCEDURE: Using the collector characteristic curves determine the beta of the device. Select a value of $V_{CE}$ of for instance 5 volts. Calculate the change in base current and the change in collector current when moving from curve one to curve two or one to three, etc.

Example: The difference of base current from curve one to two is 10uA. The difference of collector current from curve one to two at a $V_{CE}$ of 5 volts is 1.8mA.

$$B\ (\text{beta}) = \frac{\Delta\ I_C}{\Delta\ I_B} = \frac{1.8\text{mA}}{10\text{uA}} = 180$$

Calculate the beta for each value of $V_{CE}$ as indicated in the provided chart. Calculate for the change in curves 1 to 2, 2 to 3 and 1 to 3.

| $V_{CE}$ | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Curves 1 & 2 | | | | | | |
| Curves 2 & 3 | | | | | | |
| Curves 1 & 3 | | | | | | |

18 points

PROCEDURE: Using the beta value calculated at a $V_{CE}$ of 5 volts with curves 2 & 3 calculate the transistor's alpha using the provided formula.

$$\text{Alpha} = \frac{\text{Beta}}{\text{Beta} + 1} = \underline{\hspace{3cm}}$$

NOTE: Use data in darkened box in above chart.

Lab #5 Cont.

# ET 110
# Solid State
# AC COMMON BASE AMPLIFIER

Lab #6
30 points

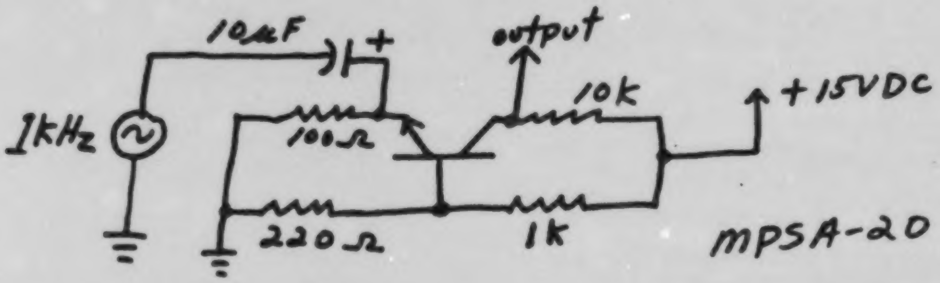
Name(s) ______________________________

______________________________

**OBJECTIVE:** To observe the input and output waveforms of a common base audio amplifier and to measure the system gain.

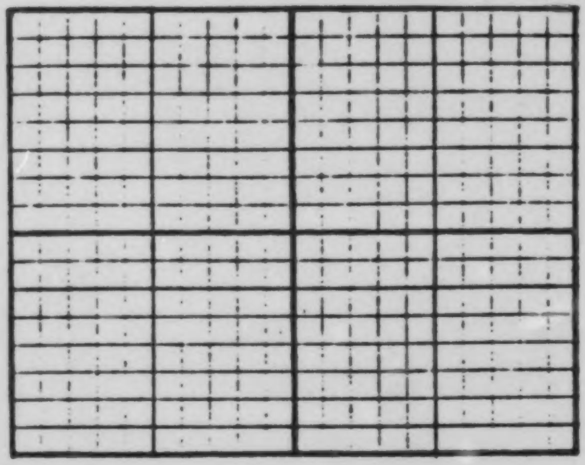
**MATERIALS:** MPSA-20 NPN transistor (417-801), 100 ohm, 220 ohm, 1k ohm, 10k ohm resistors, 10uf electrolytic capacitor.

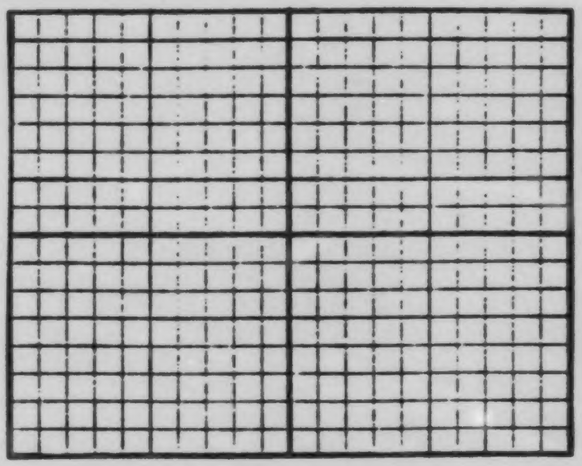
**CIRCUIT:**



**PROCEDURE:** Construct the common base audio amplifier from the given circuit. Attach the 600 ohm output of the function generator to the negative side of the 10uf capacitor. Set the generator on sine at a frequency of 1KHz plus or minus 10%. Apply 15VDC to the circuit. Attach the input lead of the oscilloscope to the emitter of the transistor. Adjust the generator for a 1Vpp signal at the transistor emitter. (Note: The ground lead of the generator, the scope and the power supply must all be connected together.) Attach the second lead of the scope to the collector of the transistor (circuit output.)

**PROCEDURE:** Record the input and output waveforms, pp voltages and phase relationships in the provided charts.





13 points INPUT WAVEFORM OUTPUT WAVEFORM

Input ____________ Vpp Output ____________ Vpp

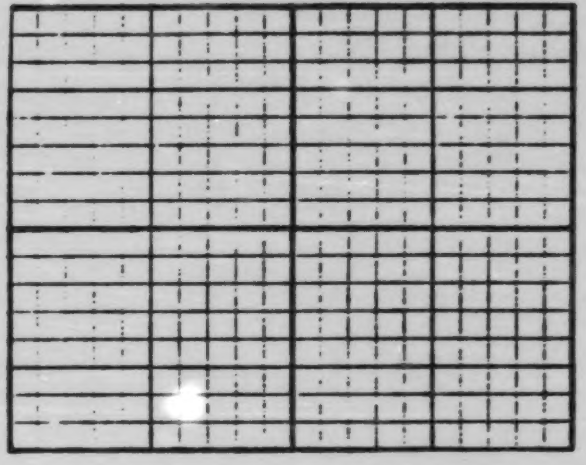
The phase relationship of the input vs the output signals are

________________ degrees.

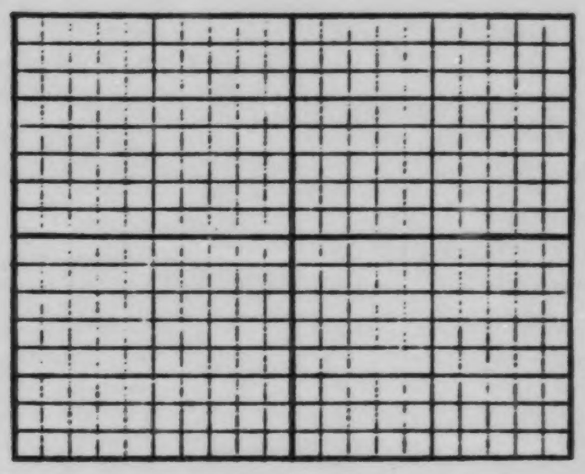
**PROCEDURE:** Calculate the voltage gain of the circuit using the measured values of input and output voltages. Use the formula Voltage Gain = $E_{out}/E_{in}$.

2 points Voltage Gain = ______________ = ______

**PROCEDURE:** Increase the input signal to a value that will cause the output signal to just start to distort. At the start of this output signal distortion record the input and output waveforms. Record the input and output waveforms, pp voltages and phase relationships in the provided charts. (If no distortion occurs, use the maximum available input voltage.)



INPUT WAVEFORM



OUTPUT WAVEFORM

13 points

Input _________ Vpp Output ______________ Vpp

The phase relationship of the input vs the output signals are

__________ degrees.

**PROCEDURE:** Calculate the voltage gain of the circuit using the new values of input and output voltages.

2 points Voltage gain = _____________ = ______

ET 110
Solid State
# AC COMMON EMITTER AMPLIFIER

Lab #7
30 points

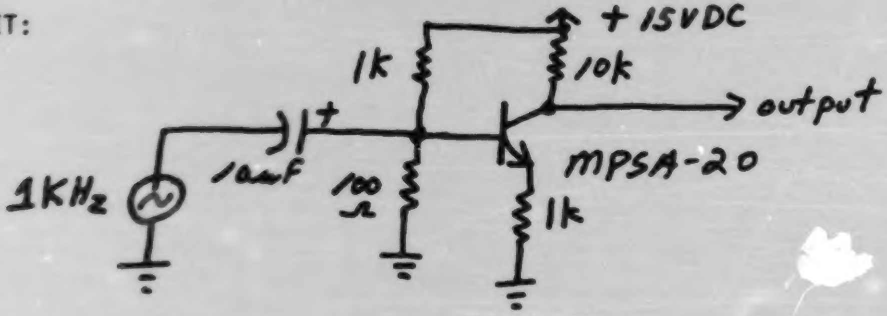
Name(s) ______________________________

______________________________

**OBJECTIVE:** To observe the input and output waveforms of a common emitter audio amplifier and to measure the system gain.

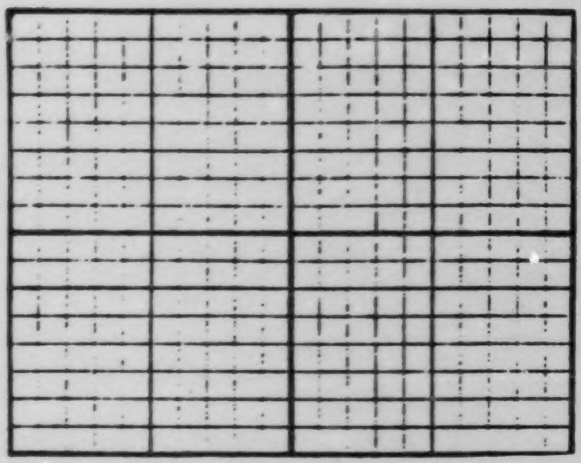
**MATERIALS:** MPSA-20 NPN transistor (417-801), 100 ohm, two 1k ohm, 10k ohm resistors, 10uf capacitor.

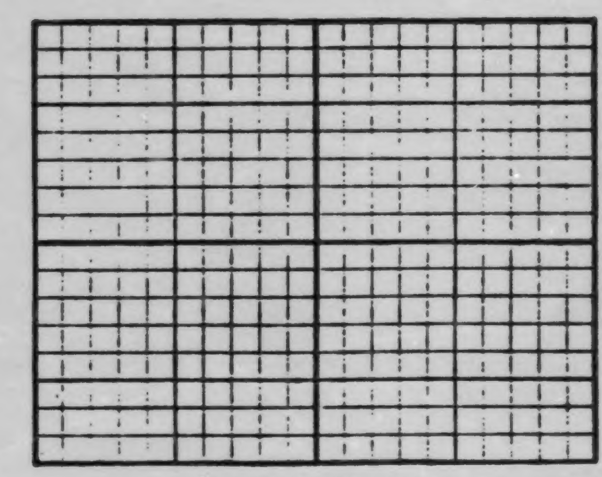
**CIRCUIT:**



**PROCEDURE:** Construct the common emitter audio amplifier from the given circuit. Attach the 600 ohm output of the function generator to the negative side of the 10uf capacitor. Set the generator on sine at a frequency of 1KHz plus or minus 10%. Apply 15VDC to the circuit. Attach the input lead of the oscilloscope to the base of the transistor. Adjust the generator for a 1Vpp signal at the transistor base. Attach the second lead of the scope to the collector of the transistor (circuit output).

**PROCEDURE:** Record the input and output waveforms, pp voltages and phase relationships in the provided charts.





13 points INPUT WAVEFORM OUTPUT WAVEFORM

Input ____________ $V_{pp}$ Output ______________ $V_{pp}$

The phase relationship of the input vs the output signals are

________________ degrees.

PROCEDURE: Calculate the voltage gain of the circuit using the measured values of input and output voltages. Use the formula Voltage Gain = $E_{out}/E_{in}$.

2 points Voltage Gain = ______________ = ☐

PROCEDURE: Increase the input signal to a value that will cause the output signal to just start to distort. At the start of this output signal distortion record the input and output waveforms. Record the input and output waveforms, pp voltages and phase relationships in the provided charts. (If no distortion occurs, use the maximum available input voltage.)

13 points INPUT WAVEFORM OUTPUT WAVEFORM

Input _________ $V_{pp}$ Output ______________ $V_{pp}$

The phase relationship of the input vs the output signals are

__________ degrees.

PROCEDURE: Calculate the voltage gain of the circuit using the new values of input and output voltages.

2 points Voltage gain = _____________ = ☐

ET 110
Solid State
# AC COMMON COLLECTOR AMPLIFIER

Lab #8
30 points

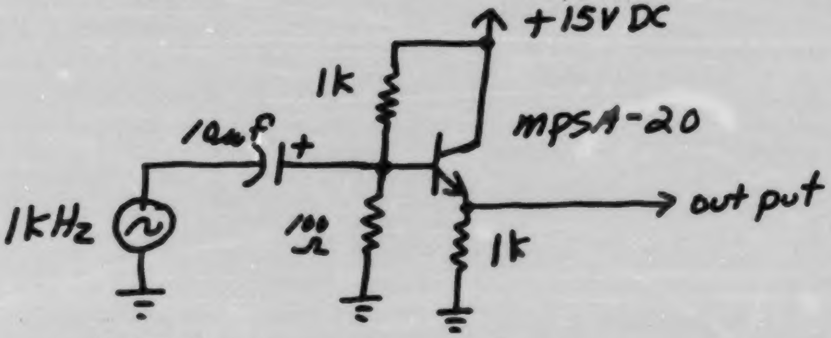
Name(s) ______________________________

______________________________

OBJECTIVE: To observe the input and output waveforms of a common collector audio amplifier and to measure the system gain.

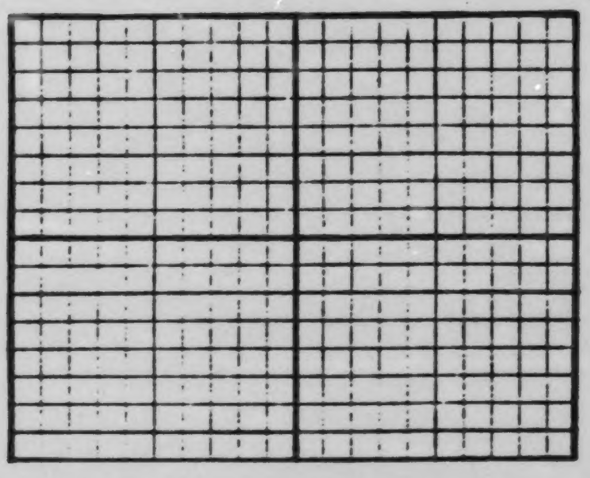
MATERIALS: MPSA-20 NPN transistor (417-801), 100 ohm, two 1k ohm resistors, 10uf capacitor.

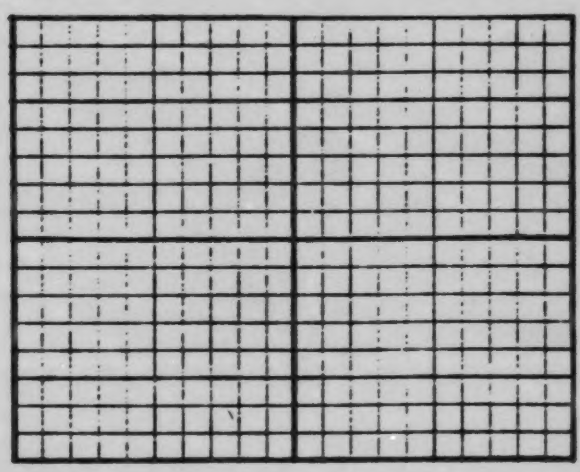
CIRCUIT:



PROCEDURE: Construct the common collector audio amplifier from the given circuit. Attach the 600 ohm output of the function generator to the negative side of the 10uf capacitor. Set the generator on sine at a frequency of 1KHz plus or minus 10%. Apply 15VDC to the circuit. Attach the input lead of the oscilloscope to the base of the transistor. Adjust the generator for a 1Vpp signal at the transistor emitter. Attach the second lead of the scope to the emitter of the transistor (circuit output.)

PROCEDURE: Record the input and output waveforms, pp voltages and phase relationships in the provided charts.





13 points

INPUT WAVEFORM

OUTPUT WAVEFORM

Input ____________ $V_{pp}$ Output ______________ $V_{pp}$

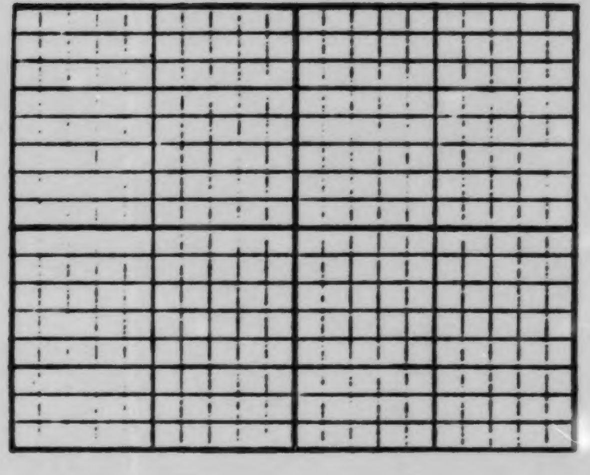
The phase relationship of the input vs the output signals are

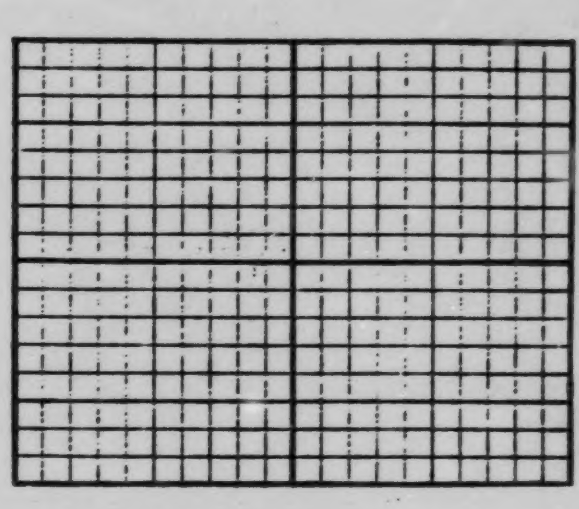
________________ degrees.

PROCEDURE: Calculate the voltage gain of the circuit using the measured values of input and output voltages. Use the formula Voltage Gain = $E_{out}/E_{in}$.

2 points Voltage Gain = ______________ =

PROCEDURE: Increase the input signal to a value that will cause the output signal to just start to distort. At the start of this output signal distortion record the input and output waveforms. Record the input and output waveforms, pp voltages and phase relationships in the provided charts. (If no distortion occurs, use the maximum available input voltage.)





13 points INPUT WAVEFORM OUTPUT WAVEFORM

Input ________ $V_{pp}$ Output ______________ $V_{pp}$

The phase relationship of the input vs the output signals are

__________ degrees.

PROCEDURE: Calculate the voltage gain of the circuit using the new values of input and output voltages.

2 points Voltage gain = _____________ =

ET 110
Solid State
# AMPLIFIER THERMAL STABILITY

Lab #9
36 points

Name(s) ______________________________

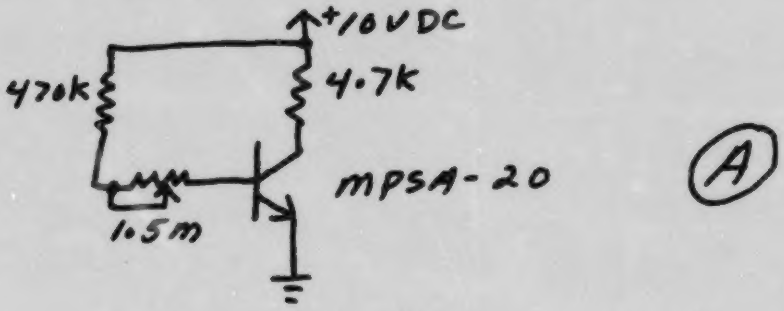
______________________________

**OBJECTIVE:** To observe the effects of thermal instability on a variety of amplifier biasing schemes.

**MATERIALS:** MPSA-20 (417-801), 2.2k ohm, 4.7k ohm, 10k ohm, 22k ohm, 470k ohm, 1.5M ohm pot

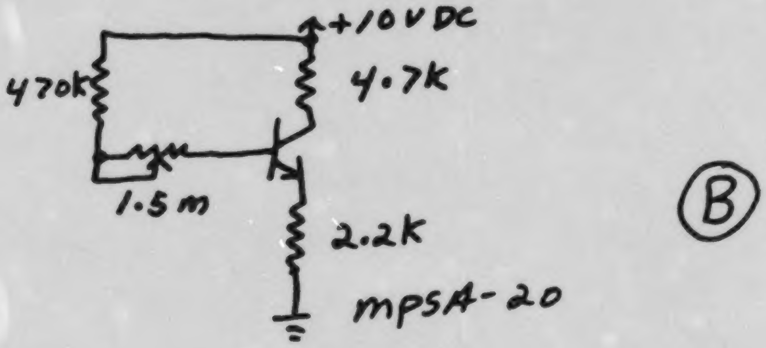
**EQUIPMENT:** Power supply, Proto-board, Soldering iron, DMM

**CIRCUIT:**



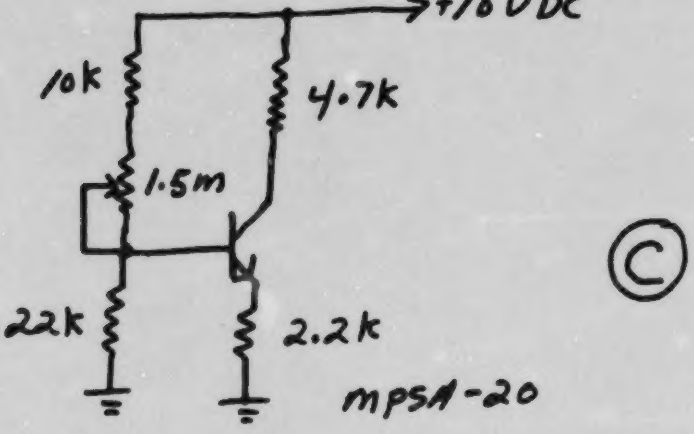
**PROCEDURE:** Construct circuit "A". Apply 10VDC as indicated. Adjust the 1.5M ohm pot for a $V_{CE}$ of 4 volts. Leave the DMM connected across $V_{CE}$. Using a hot soldering iron, apply the tip of the iron to the flat side of the transistor for exactly 20 seconds. At the end of 20 seconds record the $V_{CE}$ in the provided chart. Allow at least 5 minutes for the transistor to cool before continuing or repeating the experiment. To calculate the $\Delta$ $V_{CE}$ substract the hot $V_{CE}$ from the cold $V_{CE}$ and record in the chart.

**CIRCUIT:**



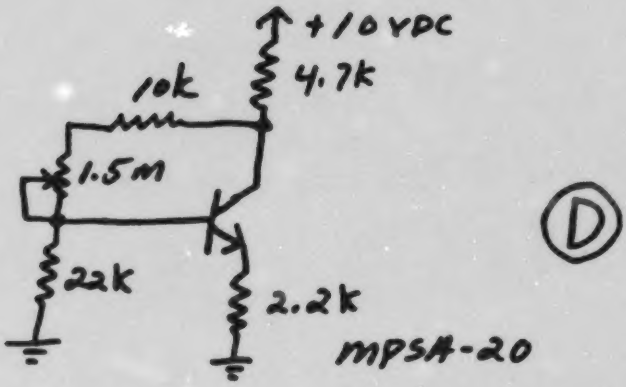
**PROCEDURE:** Construct circuit "B". Adjust the 1.5M ohm pot for a $V_{CE}$ of 5 volts. Apply heat for 20 seconds and record the data in the same manner as in the previous steps.

CIRCUIT:


+10 VDC
10k
4.7k
1.5m
22k
2.2k
mpsA-20
C

PROCEDURE: Construct circuit "C". Adjust the pot for a $V_{CE}$ of 5 volts. Again apply heat (20 seconds) and record the requested data.

CIRCUIT:


+10 VDC
10k
4.7k
1.5m
22k
2.2k
mpsA-20
D

PROCEDURE: Construct circuit "D". Adjust the pot for a $V_{CE}$ of 5 volts. Apply heat for 20 seconds and record the requested data.

ET 110
Solid State
VOLTAGE DIVIDER BIAS & THE COMMON EMITTER AMPLIFIER

Lab #10
34 points

Name(s) ______________________

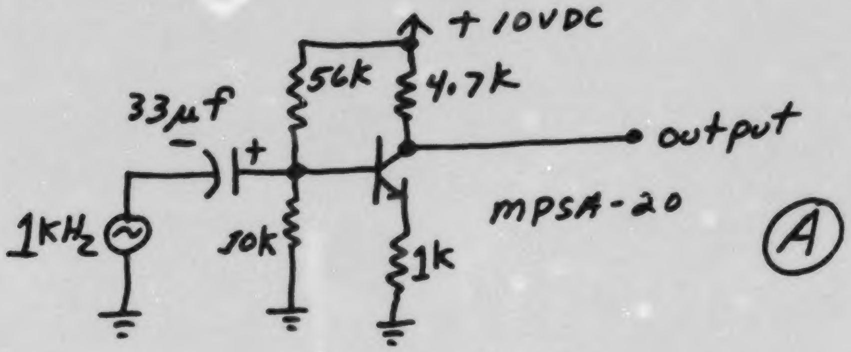
______________________

**OBJECTIVE:** To observe the electrical characteristics of a common emitter amplifier using a combination of voltage divider and emitter feedback bias.

**MATERIALS:** MPSA-20 (417-801), 1k ohm, 4.7k ohm, 56k ohm, 10k ohm, 100k ohm, 100k ohm pot, 3-33uf capacitors

**EQUIPMENT:** Power supply, Proto-board, Function generator, Oscilloscope, DMM

**CIRCUIT:**



**PROCEDURE:** Construct circuit "A". Attach one lead of the oscilloscope to the transistor base and the other lead to the collector. This will effectively measure the input and output signals. Apply a 1 KHz sine wave to the input and increase the input level until the output signal just starts to clip. Decrease the level of the input signal just enough to produce a clean (unclipped) sine wave output. Measure the peak-to-peak level of both the input and output signals. Determine the voltage gain and record the requested data.

(Voltage gain $= \frac{V_{out}}{V_{in}}$ )

| Circuit | PP Input | PP Output | Voltage Gain |
|---|---|---|---|
| A | | | |
| B/C | | | |

12 points

| Circuit | Cold $V_{CE}$ | Hot $V_{CE}$ | $\Delta V_{CE}$ |
|---|---|---|---|
| A | | | |
| B | | | |
| C | | | |
| D | | | |

24 points

PROCEDURE: Answer the following questions:

1. The circuit that produced the greatest change in $\Delta V_{CE}$ is circuit ______.

2. The circuit that produced the least change in $\Delta V_{CE}$ is circuit ______.

3. Each of the circuits used a different biasing scheme. Using your text as a guide, name each of the biasing schemes used. The circuits may use more than one biasing system so be sure to name them all.

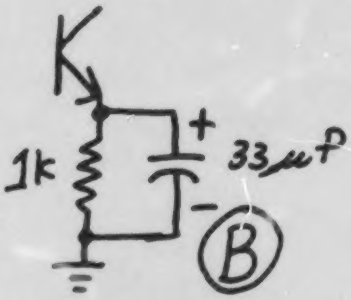
Circuit A ______________________________

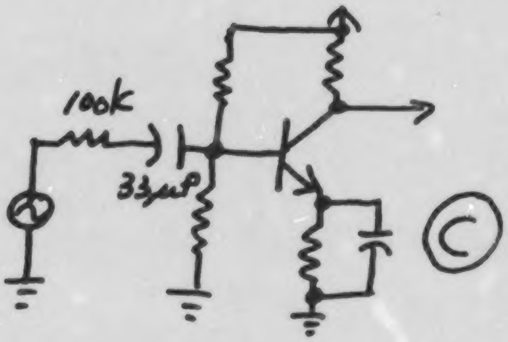
Circuit B ______________________________

Circuit C ______________________________

12 points Circuit D ______________________________

CIRCUIT:

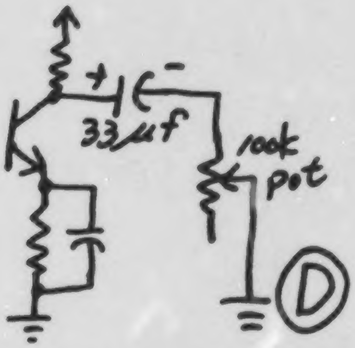


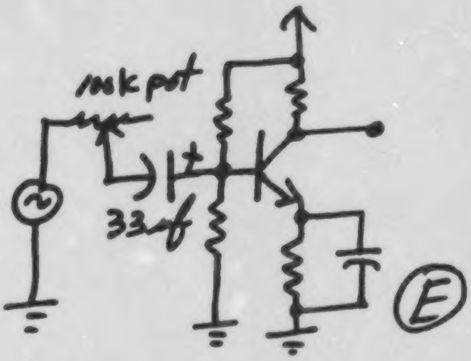


**PROCEDURE:** Modify circuit "A" by adding a 33uf capacitor across the 1k ohm emitter resistor as shown in circuit "B". Likewise add a 100k ohm resistor between the signal source and the 33uf capacitor as shown in circuit "C". Again measure the PPinput/output voltages by following the previously detailed procedures. Record the data in the provided chart.

**PROCEDURE:**
**10 points** Using your text as a guide, state the reason or reasons that account for the gain differential between the two circuits.

CIRCUIT:





**PROCEDURE:** Attach a lead of the scope to the collector. Apply an input signal (1 KHz) to produce an undistorted output voltage of any convenient value. Record the PP value in the provided chart. Without disturbing the output voltage add a 33uf capacitor and a 100k ohm pot to the collector as shown in diagram "D". To measure the output resistance of the amplifier it will be necessary to adjust the added 100k ohm pot so that the output voltage is one-half the value of the voltage measured without the pot connected in circuit "D". Record this value. Remove the pot without altering its value. Measure the resistance of the pot with the DMM using the same two leads from the pot that were originally connected to the capacitor and ground. Record this resistance value.

| Circuit | Input voltage | Output voltage | 1/2 voltage | Pot resistance |
|---|---|---|---|---|
| D | ——— | | | |
| E | | ——— | | |

12 points

PROCEDURE: Remove the fixed 100k ohm resistor as added in circuit "C" and replace with a 100k ohm pot. While measuring the output voltage (collector PP voltage) adjust the input pot and signal generator to obtain an undistorted output signal of any convenient value. Record in the provided chart. Adjust the pot to produce an output voltage that is one-half of the previous value. Remove the pot and measure its resistance as in the previous example. This value is the input resistance of the circuit. Record in the provided chart.

ET 110
Solid State
THE N-CHANNEL FET

Lab #11
64 points

Name(s) ____________________

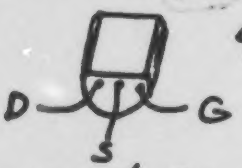
____________________

**OBJECTIVE:** To observe the operation of an N-channel field effect transistor

**MATERIALS:** N-channel FET (417-291), 2-1k ohm, 100k ohm pot, 1k ohm pot, 100 ohm

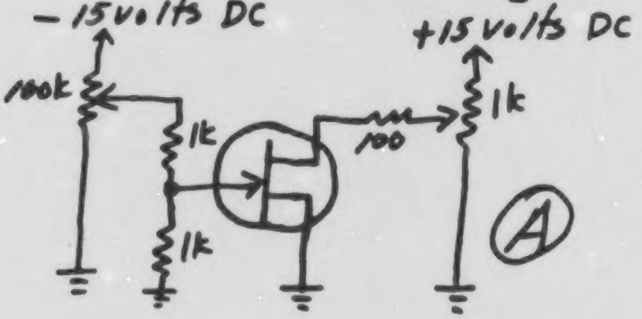
**EQUIPMENT:** Power supply, Proto-board

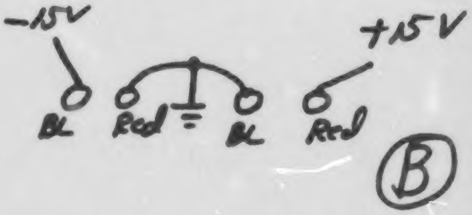
**PIN-OUT:**



417-291

**CIRCUIT:**





**PROCEDURE:** Construct circuit "A" making note of the fact that the device requires both a negative and positive voltage from the power supply. If you are unsure of the proper power supply connections see circuit "B". Apply power to the gate circuit only at this time. Adjust the 100k ohm pot for a voltage as measured from gate to source of zero volts. Turn on the drain supply and adjust the 1k ohm pot for a drain to source voltage of one volt. Measure the voltage drop across the 100 ohm fixed resistor (drain resistor) and calculate the drain current using the indirect method of current calculation. Review the provided chart. As indiated, it will be necessary to present the gate-source voltage while observing the change in drain current. This data will later be plotted and will produce the typical FET characteristic curves.

$V_{GS}$ = 0 volts

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $V_{DS}$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| $E_{R1}$ | | | | | | | | |
| $I_{R1}$ | | | | | | | | |

$V_{GS}$ = -.25 volts

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $V_{DS}$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| $E_{R1}$ | | | | | | | | |
| $I_{R1}$ | | | | | | | | |

| $V_{GS}$ = -.5 volts | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $V_{DS}$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| $E_{R1}$ | | | | | | | | |
| $I_{R1}$ | | | | | | | | |

$V_{GS}$ = -.75 volts

| $V_{DS}$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $E_{R1}$ | | | | | | | | |
| $I_{R1}$ | | | | | | | | |

32 points

PROCEDURE: Using the calculated values of $I_{R1}$ which is the drain current and the voltage drop across the drain source, plot a characteristic curve for each value of $V_{GS}$. Plot the $I_D$ on the vertical axis in MA and $V_{DS}$ in volts on the horizontal axis. Use a scale of one inch per volt and one inch per milliampere. Use the provided graph paper attached to the last page of this lab.

20 points

PROCEDURE: Review the data presented in the text on calculating the transconductiance of a FET. Use a $V_{DS}$ value of 6 volts for this transconductance measurement. This $V_{DS}$ value will be above the pinch-off voltage, i.e. in the flat part of the curve. Observe the change in $I_D$ when $V_{GS}$ changes from 0 to -.25 volts. Use the formula: Transconductance is equal to $\frac{\Delta I_D}{\Delta V_{GS}}$ Remember, transconductance is measured in mohs.

5 points Transconductance = $\frac{\Delta I_D}{\Delta V_{GS}}$ = ______________ = $\boxed{\phantom{xxxxxx}}$

PROCEDURE: Calculate the transconductance with a $V_{DS}$ of 7 volts when $V_{GS}$ changes from -.25 volts to a -.50 volts.

5 points Transconductance = $\frac{\Delta I_D}{\Delta V_{GS}}$ = ______________ = $\boxed{\phantom{xxxxxx}}$

Lab #11 Cont.

# ET 110
# Solid State
# DEPLETION MODE MOSFET

Lab #12 Name(s)__________________
60 points

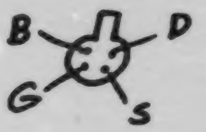
__________________

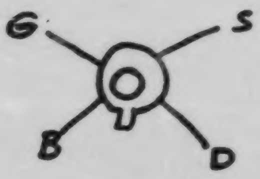
**OBJECTIVE:** To observe the operation of a N-channel depletion mode MOSFET

**MATERIALS:** N-channel MOSFET (417-935), 1k ohm, 4.7k ohm, 10k ohm, 100k ohm pot, 1k ohm pot

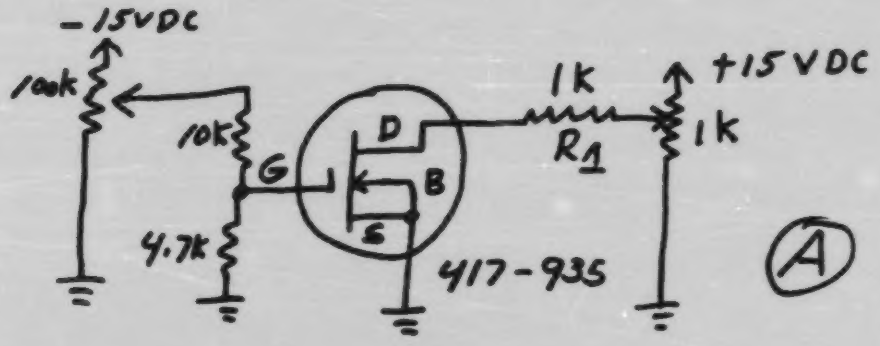
**EQUIPMENT:** Power supply, Proto-board, DMM

**PIN-OUT:** Bottom View Top View





**CIRCUIT:**



**PROCEDURE:** Examine the MOSFET device. Take note of the shorting ring that is used to protect the device from static electricity. Review the base diagram of the MOSFET to insure the correct placement of the device in the circuit. When constructing the circuit DO NOT place the MOSFET into the circuit until all components are interconnected. At that point, the MOSFET may be inserted and the shorting ring removed.

Construct circuit "A". Apply power as indicated and adjust the 100k ohm pot for a gate to source voltage of zero volts. Adjust the 1k ohm pot for a drain to source voltage of plus .5 volts.

Review the tables which have been provided for the recording of the voltage drop across $R_1$, the current through $R_1$ and the value of the voltage drop across the drain/source at a fixed value of $V_{GS}$. Set the $V_{GS}$ at the requested value. Using the 1k ohm pot, vary the $V_{DS}$ to the specified values and record $E_{R1}$ and calculate by the indirect method $I_{R1}$ (drain current). It will be necessary to rewire the power supply to achieve a positive voltage on the gate as requested for a $V_{GS}$ of plus .5 volts. Make note of this procedural change as the other $V_{GS}$ voltages are negative or zero.

| $V_{GS}$ = 0 volts | | | | | |
|---|---|---|---|---|---|
| $V_{DS}$ | .5 | 1 | 2 | 3 | 4 |
| $E_{R1}$ | | | | | |
| $I_{R1}$ | | | | | |

$V_{GS}$ = -.5 volts

| $V_{DS}$ | .5 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| $E_{R1}$ | | | | | |
| $I_{R1}$ | | | | | |

$V_{GS}$ = +.5 volts

| $V_{DS}$ | .5 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| $E_{R1}$ | | | | | |
| $I_{R1}$ | | | | | |

30 points

PROCEDURE: Using the attached graph paper plot the characteristic curves for the device. Plot $I_D$ on the vertical axis (11 inch side) in milliampers and $V_{DS}$ in volts on the horozontal side (8½ inch side).

20 points Label each curve as to its $V_{GS}$ value.

PROCEDURE: After the completion of the lab and prior to circuit disassembly reinstall the MOSFET shorting ring before removing the FET from the circuit. As always, remove power before removing any components from the circuit.

PROCEDURE: Answer the following questions based on the lab and text information.

5 points 1. Describe the procedure to be used to extend the curves just ploted into the devices pinch-off region or farther into that region.

1 point 2. The region below pinch-off is also known as the devices _______ region.

2 points 3. A $V_{GS}$ of __________ produced the maximum value of $I_D$ while a $V_{GS}$ value of __________ produced a minimum value of $I_D$.

2 points 4. If an enhancement mode N-channel MOSFET were to replace the depletion mode device a $V_{GS}$ value of + 5 volts would produce a _______________ $I_D$ while a $V_{GS}$ of -.5 volts would produce a
high-low-zero

_______________ $I_D$.
high-low-zero

ET 110
Solid State
SILICON CONTROLLED RECTIFIER

Lab #13
27 points

Name(s) ______________________

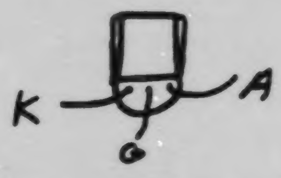
______________________

**OBJECTIVE:** To observe the operation of an SCR in a DC and AC control circuit.

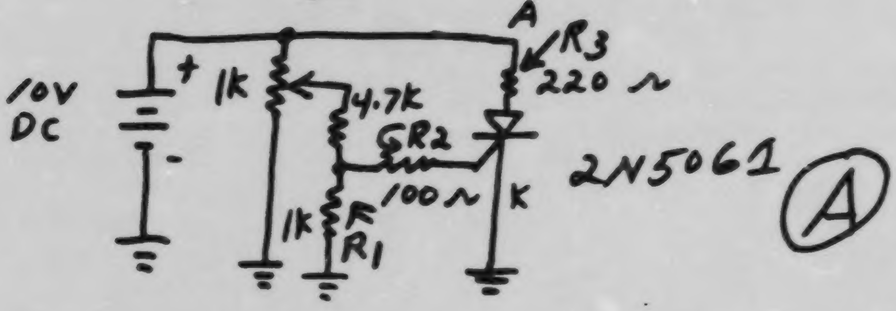
**MATERIALS:** 2N5061 (57-624), Germanium diode (56-602), Silicon diode (56-28), 4.7k ohm, 1k ohm, 220 ohm, 100 ohm, 1k pot, 100k pot, Lamp (412-601)

**EQUIPMENT:** Power supply, Proto-board, Oscilloscope, DMM, 10-15 VAC transformer

**PIN-OUT:**



**CIRCUIT:**



**PROCEDURE:** Construct circuit "A". Prior to applying power to the circuit adjust the 1k pot for a resistance of zero ohms between ground and the wiper arm of the pot. Apply power to the circuit and measure the voltage drops across R1, R2, R3 and the SCR's anode-cathode. Using ohm's law calculate the current flow through R2 ($I_G$) and R3 ($I_F$ the SCR's forward current). These values will indicate the voltage and currents present when the SCR is in its off state.

| | OFF | ON |
|---|---|---|
| $V_{R1}$ | | |
| $V_{R2}$ | | |
| $V_{R3}$ | | |
| $V_{AK}$ | | |
| $I_{R2}$ | | |
| $I_{R3}$ | | |

12 points

PROCEDURE: Connect the DMM across the SCR's anode and cathode. Slowly adjust the 1k pot for a noticeable change in voltage. Record the SCR's on state values in the previous chart.

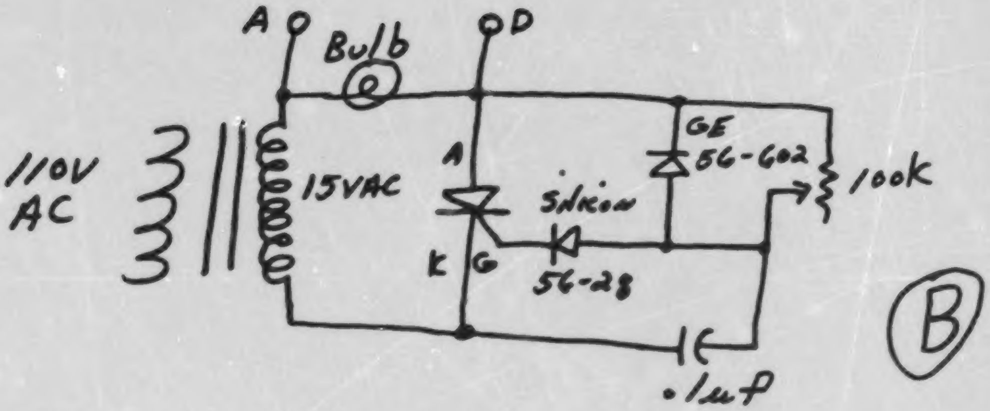
Reduce the gate current to zero. Use the voltage drop across R2 as a indicator of current.

1 point 1. Did the SCR change from its on state to its off state?

3 points 2. Explain the reason why the SCR performed as it did in the previous question.

3 points 3. Determine the procedure necessary to unlatch the SCR. Your procedure is:

CIRCUIT:



PROCEDURE: Construct circuit "B" using any available 10-15 VAC source to power this half-wave phase control circuit. Apply power to the circuit and observe the position of the pot for various output intensities.

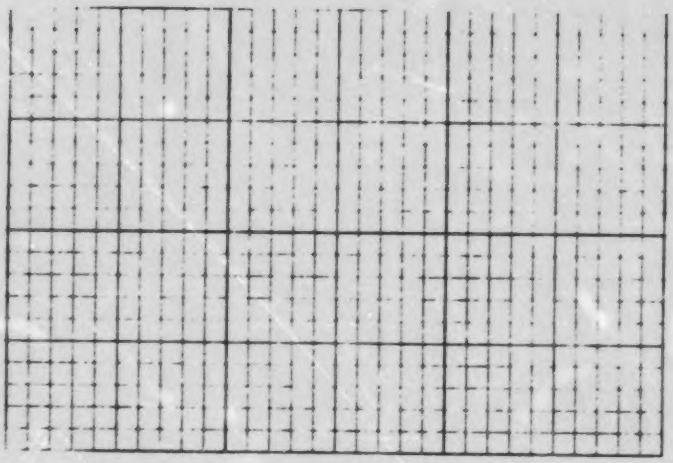
1 point 1. The pot is at __________ ohms for maximum bulb brilliance.

1 point 2. The pot is at __________ ohms for medium bulb brilliance.

1 point 3. The pot is at __________ ohms for no bulb brilliance.

PROCEDURE: Connect the scope between points A and D with the scope ground at point D. Draw the waveforms for maximum, medium and just barely glowing bulb brilliance. Label each waveform as ti intensity.

5 points



[illegible] 110
Solid State

# UJT RELAXATION OSCILLATOR

Lab #14
53 points

Name(s) ____________________

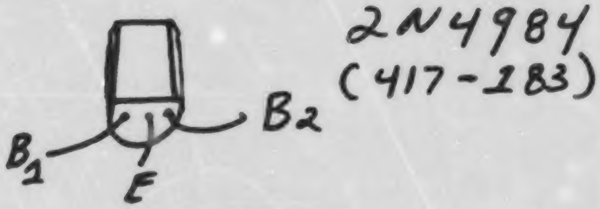
____________________

**OBJECTIVE:** To observe the operation of a UJT relaxation oscillator

**MATERIALS:** UJT (517-183), 100 ohm, .luf capacitor, a variety of capacitor and resistor values

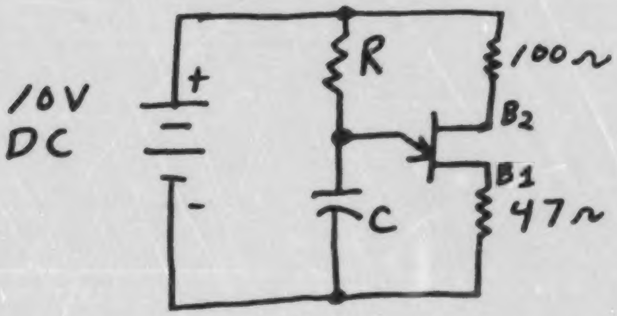
**EQUIPMENT:** Power supply, Proto-board, Oscilloscope, Calculator

**PIN-OUT:**



2N4984
(417-183)

**CIRCUIT:**



**PROCEDURE:** Construct the UJT circuit using a .luf capacitor for C and a 10k ohm resistor for R. Conect the scope to the devices emitter and $B_1$ terminals. Record the waveforms at these two points, the frequency of oscillation and period.

5 points

2 points

Period ____________ seconds
Frequency ____________ Hz

PROCEDURE: Select six values of capacitors and resistor combinations for C and R that will produce circuit oscillations. Record the chosen values for R and C, measure the resultant period, and calculate the frequency of oscillation from the measured period.

| Values | | Measured Period | Measured Frequency | Calculated Frequency | % Error |
|---|---|---|---|---|---|
| R | C | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

30 points

PROCEDURE: Observe the relationship of the circuit RC values to the resultant period/frequency. Modify the typical series RC time constant formula to produce a new formula that will predict with a relative degree of accuracy the UJT's oscillation frequency.

DEVELOPED FORMULA

10 points

PROCEDURE: Once the formula is developed, use the previous values chosen for R and C to calculate the frequency of operation. Place the answers in the previous chart under the column "Calculated Frequency."

Compare the calculated frequency with the actual measured frequency and derive the percent of error between the two values. Assign a plus or minus to the percent value as follows

1. Always use the measured frequency as the reference.
2. If the measured frequency $>$ the calculated frequency assign a plus to the derived percent value.
3. If the measured frequency $<$ the calculated frequency assign a minus to the derived percent value.

EXAMPLE: Measured Frequency 540 Hz

Calculated Frequency 528 Hz

$1-\frac{528}{540} = 1- .977 = .022 \times 100 = 2.2\%$

Measured > calculated = +%

Percent error = + 2.2%

Measured Frequency 375 Hz

Calculated Frequency 412 Hz

$1-\frac{375}{412} = 1- .910 = .0898 \times 100 - 8.98\%$

Measured < calculated = -%

Percent error = - 8.98%

# ELECTRONIC MAINTENANCE TECHNOLOGY PROGRAM

## DIGITAL CIRCUIT FUNDAMENTALS I

## ET 115

Learning for a Lifetime
WASHBURN UNIVERSITY
School of Applied and Continuing Education

# ELECTRONIC MAINTENANCE TECHNOLOGY PROGRAM
# ET 115
# DIGITAL CIRCUIT FUNDAMENTALS I

SCHOOL OF APPLIED AND CONTINUING EDUCATION
WASHBURN UNIVERSITY

# FORWARD

In 1983, the Vocational Administration Section of the Kansas State Department of Education provided a grant to the School of Applied and Continuing Education at Washburn University to develop a two year associate degree program in the emerging high technology field of electronics. These curriculum materials are one of the products of that project. This curriculum package includes the course syllabi, study guide, information sheets, laboratory sheets, assignments sheets and unit examinations.

The materials in this package have been prepared in a sequence that best matched our situation. The individual instructor may add, delete or rearrange to his/her own needs.

Assistant Professor, Jim Jaworski is the author of these curriculum materials and is to be congratulated for his work. Our special thanks also go to the support staff in the School for their assistance with graphics, typing and editing of these materials.

William S. Dunlap

and

Reid A. Holland
Project Directors

Funding for this project was provided through the Research Coordinating Unit, Division of Community Colleges and Vocational Education, Kansas State Department of Education under Public Law 94-482, subpart 3, section 132.

State Reference No. 85-132-03

The activity which is the subject of this report was supported in whole or in part by funds from Kansas State Department of Education, Division of Vocational and Post Secondary Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Kansas Department of Education or the Division of Community Colleges and Vocational Education, and no official endorsement should be inferred.

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School of Applied and Continuing Education
Washburn University

ET 115 - Digital Circuit Fundamentals I
3 Semester Hours
Spring 1985
Syllabus

J. Jaworski, Professor

## INTRODUCTION

The use of digital circuits in electronics has increased over the past 5 years and will continue to grow as the cost of digital circuitry decreases with new circuit production methods. With this increase in digital usage, it is of paramount importance that individuals responsible for the upkeep of these systems understand the basics of digital circuitry. These skilled individuals will become increasingly valuable as more and more digital based equipment reaches the market place.

## COURSE ORGANIZATION

The class will meet twice a week. On Tuesday evening the class runs from 5:20 to 7:20 pm. On Thursday evening the class is in session from 5:20 to 7:20 pm. Lecture and lab sessions will be interchanged at the discretion of the instructor to best facilitate the presentation of course material.

## TENTATIVE COURSE TIMETABLE

The material covered will basically follow the below schedule subject to needed instructor modification.

| | | | |
|---|---|---|---|
| January | 22 | Tuesday | Introduction |
| | 29 | Tuesday | Introduction to Digital Techniques |
| | 31 | Thursday | Semiconductor Devices |
| February | 5 | Tuesday | Semiconductor Devices (continued) |
| | 7 | Thursday | Digital Logic Circuits |
| | 12 | Tuesday | Digital Logic Circuits (continued) |
| | 14 | Thursday | Logic Circuits Lab |
| | 19 | Tuesday | Test #1 |
| | 21 | Thursday | Digital IC's |
| | 26 | Tuesday | Digital IC's (continued) |
| | 28 | Thursday | Digital IC's Lab |
| March | 5 | Tuesday | Boolean Algebra |
| | 7 | Thursday | Boolean Algebra (continued) |
| | 12 | Tuesday | Boolean Algebra Lab |
| | 14 | Thursday | Test #2 |
| | 19 | Tuesday | NO CLASSES SPRING BREAK |
| | 21 | Thursday | NO CLASSES SPRING BREAK |
| | 26 | Tuesday | Flip Flops |
| | 28 | Thursday | Flip Flops (continued) |

| | | | |
|---|---|---|---|
| April | 2 | Tuesday | Sequential Logic |
| | 4 | Thursday | Sequential Logic (continued) |
| | 9 | Tuesday | Combinational Logic |
| | 11 | Thursday | Combinational Logic (continued) |
| | 16 | Tuesday | Combinational Logic Lab |
| | 18 | Thursday | Digital Design |
| | 23 | Tuesday | Digital Design (continued) |
| | 25 | Thursday | Semiconductor Memories |
| | 30 | Tuesday | Semiconductor Memories (continued) |
| May | 2 | Thursday | Data Conversion |
| | 7 | Tuesday | Data Conversion (continued) |
| | 14 | Tuesday | Final Examination |

## COURSE OBJECTIVES

The objectives of this course are adequately stated at the beginning of each chapter in your textbook. These objectives reflect the needs and desired outcomes of this course.

## COURSE REQUIREMENTS

Text: Heath Company, Digital Techniques Book 1 & 2

## GRADING SCALE

All class evaluation will be based on the grading scale listed below. The indicated percentage designates the bottom of the respective grade zone, i.e., 85% is the bottom of the B's. An individual earning an 82% would receive a grade of C, etc.

| | |
|---|---|
| A | 93% |
| B | 85% |
| C | 77% |
| D | 69% |

Individual grades will not be issued during the course of the term. It is your responsibility to record all test scores and calculate any applicable letter grades. As an example: a test has 86 possible points. Your score is 76. Divide 76 by 86 and the percentage is 88.4%. The equivalent letter grade from the chart is a grade of "B".

## EVALUATION

(50% of the total grade)

All major evaluations will contribute an equal percentage regardless of the number of evaluations during the course of the term. The number of evaluations may range from two through five with the following table listing the applicable percentages:

| | |
|---|---|
| Two Evaluations | 25.0% each |
| Three Evaluations | 16.6% each |
| Four Evaluations | 12.5% each |

The Final Examination will be given as listed in the spring schedule of classes. The Final Examination date and time is: Tuesday, May 14, 1985, beginning at 5:20 pm and ending at 8:20 pm. Alterations in final times and dates are possible with class, instructor and Dean's consent.

# EVALUATION REVIEW PROCEDURES

The following procedures will be utilized for the review of all major evaluations:

1. Answers will be given in class to check for mechanical grading errors. Comments regarding the agreement or disagreement to a response will not be invited at this time.

2. If a disagreement exists, follow the procedure below:

   A. On the top of the front page of the test, write the number of the question you disagree with.

   B. Locate the page on which the question you disagree with appears. On the back of this page, write your reasons why your response should be considered correct.

   C. Repeat this procedure as often as necessary.

3. Sufficient time will be provided for the individual accomplishment of step two. Those not wishing to respond are to remain silent during this period. There is to be no discussion during this period by any class member.

4. After completion of all written input, the examination will them be reviewed. All responses made during this review process will not have any bearing on any individual's grade, as only the written response will be considered.

5. During this discussion period, all writing on the examination must cease. Those continuing to respond will be considered to be cheating.

6. Individuals not participating in the test review procedures forfeit their right to alter their test score at a future date, i.e., all debate must be made in writing on the test itself.

7. Examination papers will be made available for review purposes on an individual basis. These test materials are not to leave the instructor's office.

## LAB SHEETS
(20% of the total grade)

Laboratory experiments requiring the gathering of data through the use of electronic instrumentation or the performance of a skill in an instructor assigned learning experience in student pairs are considered to be lab work.

## ASSIGNMENT/PROBLEM SHEETS
(20% of the total grade)

Individually performed instructor assigned exercises requiring the mathematical manipulation of factors for the obtainment of correct responses, i.e., materials not requiring the use of the lab or lab experiments for the obtainment of answers.

## SENSATIONALS AND HOW ABOUTS
(10% of the total grade)

An individually prepared hand-in covering sensationals and how abouts on class activities, lecture material, reading, discussion, etc.

A sensational is a reaction to a main point or topic that the individual found exceptional or sensational in nature. A how about is a questioning reaction to presented material. How abouts indicate points that are unclear and require further discussion for clarification or offers constructive alternatives to what was presented.

## QUIZZES
(Part of the S and HA total)

Quizzes are considered to be short announced or unannounced examinations consisting of ten to twenty-five points and spaced spasmodically throughout the course. In addition, quizzes cannot be made up. Generally, a missed quiz will result in a grade of zero being entered into the record for that particular quiz. However, each individual is allowed to miss one quiz without penalty.

## LATE POLICY

In general, materials to be handed in are due at the beginning of the class period. These materials are considered late if presented after the announced due date unless otherwise specified. Materials received late will not be graded.

If you anticipate being absent, these materials may be handed in early, delivered to my office (Room 124, Benton Hall), placed in my faculty mailbox, or presented by a fellow student during the regularly scheduled class period.

## WORK MISREPRESENTATION

All work produced is expected to be your own material. Plagiarism, cheating, or other forms of academic dishonesty are not tolerated. Those being observed in such circumstances will not receive credit for the course.

The instructor reserves the right to alter this syllabus as required.

ET 115
Digital
Study Guide Test #1
Chapters 1-3

Information Sheet #1

The listed statements are to act as a study guide for this examination. A thorough review of this document will significantly help in your preparation for this exam.

A listing of formulas will be allowed provided no definition of terms appears on the formula sheet. E = I x R is acceptable, volts = current x resistance is not acceptable. A calculators use is suggested for this test.

The code that minimizes speed and timing errors

Which BCD code is best for arithmetic operations

The advantages of a BCD code

The name given to transistor that is placed in parallel with its load

The voltages that can be assigned to positive logic

What is meant by parallel data handling

The advantages of serial data handling

The types of gates used in decision making logic circuits

The type of circuit used as a memory element

The type of majority carrier in P type material

The type of material the anode of a diode is made of

The characteristics of a forward and reversed biased diode

The region of a transistor that supports the major current flow

The biasing of a NPN and PNP transistor

The biasing of a transistor for cut-off, saturation and linear operation.

The number of junctions in a transistor

Digital techniques are used more now than previously because

The transistor current relationships of emitter to collector

The majority current carriers in an NPN device

Given the collector and emitter currents calculate the base current

The definition of Alpha

The definition of Beta

Given the beta and base current calculate the collector current

How the base current effects the collector-emitter current

What amount of voltage is dropped across a silicon diode

The regions a bipolar transistor can be operated in

Given the base and collector currents and beta determine in which region the device is operating

Given a set of voltages determine in which region the device is operating

Determine the power dissipated by a transistor knowing certain current and voltage data

Using transistor data design a common emitter saturated transistor switch

What the base of a transistor controls

The type of digital logic that is the simplest

Inverter inputs & outputs

The number of input combinations possible with a 4 input gate

The type of logic expression used by an AND gate and a OR gate

Given gate logic symbols develop the algebraic output equation

Develop an output truth table for given logic symbols

The input/output characteristics of an OR and an AND gate

Given a completed truth table determine the types of gates represented

Write the logic output equation given a combination of inverters and an OR gate

Given the output algebraic expression identify the gate type

The resultant gate type available when NAND and NOR gates are combined with inverters

The equivalent gate types when parallel and series SPST switches are used as circuit elements

The digital code used for man to machine communications

The code used for data transfer between computers and their output devices

The advantages of digital circuits over analog

The types of signals that are binary

What kind of devices are analog in nature

The characteristics of a digital signal

Convert a binary number to a decimal number and vice-versa

How many bits it takes to represent a decimal number

Two to Nth power can represent what maximum decimal number

The bits in a binary word

How to convert a binary 101.110 to a decimal number

What MSB stands for

How many binary states a 5 bit word represents

The method used to represent a base two number

What a BCD number looks like

How to convert a decimal to a BCD number

The maximum decimal number a BCD code can represent

## ET 115
## Digital
## TTL CHARACTERISTICS

Information Sheet #2

### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

| | |
|---|---|
| Supply Voltage $V_{CC}$ (See Note 1) | 7 V |
| Input Voltage, $V_{in}$ (See Note 1) | 5.5 V |
| Interemitter Voltage (See Note 2) | 5.5 V |
| Resistor Node Voltage, SN54121, SN74121 (See Note 1) | −5.5 V to 7 V |
| Operating Free-Air Temperature Range: Series 54 Circuits | −55°C to 125°C |
| Series 74 Circuits | 0°C to 70°C |
| Storage Temperature Range | −65°C to 150°C |

NOTES: 1. Voltage values, except interemitter voltage, are with respect to network ground terminal.
2. This is the voltage between two emitters of a multiple-emitter transistor.

### logic definition

Series 54/74 logic is defined in terms of standard POSITIVE LOGIC using the following definitions:

HIGH VOLTAGE = LOGICAL 1

LOW VOLTAGE = LOGICAL 0

### input clamping diodes

Although not shown on all schematic diagrams, all of these SSI circuits incorporate input diodes. Each clamping diode is capable of limiting negative excursions at the input to a maximum of 1.5 volts below ground, even if −12 mA of current is drawn.

### unused inputs of NAND/AND gates

6

For optimum switching times and minimum noise susceptibility, unused inputs should be maintained at a positive voltage greater than 2.4 V but not exceed the absolute maximum rating of 5.5 V. This eliminates the distributed capacitance associated with the floating input-transistor emitter, bond wire, and package lead, and ensures that no degradation will occur in the propagation delay times. Some possible ways of handling input emitters are:

a. Connect unused inputs to an independent supply voltage. Preferably, this voltage should be between 2.4 V and 3.5 V.

b. Connect unused inputs to a used input if maximum fan-out of the driving output will not be exceeded. Each input presents a full load in the logical 1 state to the driving output.

c. Connect unused inputs to $V_{CC}$ through a 1-kΩ resistor so that if a transient which exceeds the 5.5-V maximum rating should occur, the impedance will be high enough to protect the input. One to 25 unused inputs may be connected to each 1-kΩ resistor.

### input-current requirements

Input-current requirements reflect worst-case conditions over the specified recommended operating free-air temperature and $V_{CC}$ ranges. Each input, of the multiple emitter input transistors which have a 4-kΩ base resistor, requires that no more than −1.6 mA flow out of the input at a logical 0 voltage level; therefore, one load (N = 1) is −1.6 mA maximum. Each input requires current into the input at a logical 1 voltage level. This current is 40 μA maximum for each emitter of input transistors with the 4-kΩ base resistor. Currents into the input terminals are specified as positive values. Arrows on the d-c test circuits indicate the actual direction of current flow.

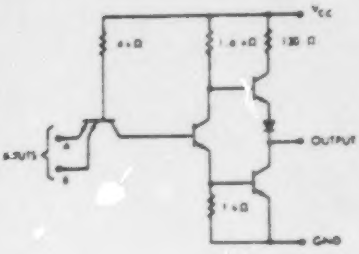
### fan-out capability

Fan-out reflects the ability of an output to sink current from a number of loads (N) at a logical 0 voltage level and to supply current at a logical 1 voltage level. Each standard output is capable of sinking current or supplying current to 10 loads (N = 10). The buffer gate is capable of sinking current or supplying current to 30 loads (N = 30). Load currents (out of the output terminal) are specified as negative values. Arrows on the d-c test circuits indicate the actual direction of current flow.

Series 54/74 circuits are well suited for driving Series 54H/74H and 54S/74S high-speed TTL and Series 54L/74L low-power TTL circuits. As examples, a Series 54/74 output, rated for a fan-out of ten (N=10), will drive eight 54H/74H loads or forty 54/74L loads.

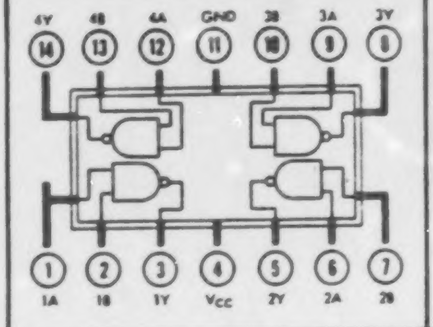
# CIRCUIT TYPES SN5400, SN7400
# QUADRUPLE 2-INPUT POSITIVE NAND GATES

## schematic (each gate)

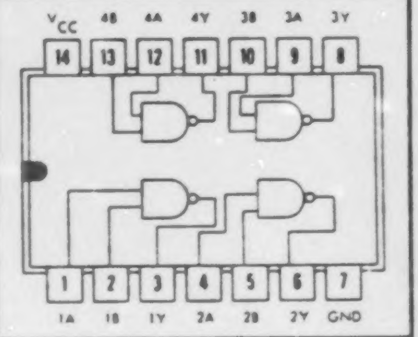


NOTE: Component values shown are nominal.

**W FLAT PACKAGE (TOP VIEW)**



**J OR N DUAL-IN-LINE PACKAGE (TOP VIEW)**



**positive logic:** $Y = \overline{AB}$

## recommended operating conditions

| | | MIN | NOM | MAX | UNIT |
|---|---|---|---|---|---|
| Supply Voltage $V_{CC}$: | SN5400 Circuits | 4.5 | 5 | 5.5 | V |
| | SN7400 Circuits | 4.75 | 5 | 5.25 | V |
| Normalized Fan-Out From Each Output, N | | | | 10 | |
| Operating Free-Air Temperature Range, $T_A$: | SN5400 Circuits | −55 | 25 | 125 | °C |
| | SN7400 Circuits | 0 | 25 | 70 | °C |

## electrical characteristics over recommended operating free-air temperature (unless otherwise noted)

| PARAMETER | | TEST FIGURE | TEST CONDITIONS[†] | | MIN | TYP[‡] | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{in(1)}$ | Logical 1 input voltage required at both input terminals to ensure logical 0 level at output | 1 | | | 2 | | | V |
| $V_{in(0)}$ | Logical 0 input voltage required at either input terminal to ensure logical 1 level at output | 2 | | | | | 0.8 | V |
| $V_{out(1)}$ | Logical 1 output voltage | 2 | $V_{CC}$ = MIN, $V_{in}$ = 0.8 V, $I_{load}$ = −400 μA | | 2.4 | 3.3 | | V |
| $V_{out(0)}$ | Logical 0 output voltage | 1 | $V_{CC}$ = MIN, $V_{in}$ = 2 V, $I_{sink}$ = 16 mA | | | 0.22 | 0.4 | V |
| $I_{in(0)}$ | Logical 0 level input current (each input) | 3 | $V_{CC}$ = MAX, $V_{in}$ = 0.4 V | | | | −1.6 | mA |
| $I_{in(1)}$ | Logical 1 level input current (each input) | 4 | $V_{CC}$ = MAX, $V_{in}$ = 2.4 V | | | | 40 | μA |
| | | | $V_{CC}$ = MAX, $V_{in}$ = 5.5 V | | | | 1 | mA |
| $I_{OS}$ | Short-circuit output current[§] | 5 | $V_{CC}$ = MAX | SN5400 | −20 | | −55 | mA |
| | | | | SN7400 | −18 | | −55 | |
| $I_{CC(0)}$ | Logical 0 level supply current | 6 | $V_{CC}$ = MAX, $V_{in}$ = 5 V | | | 12 | 22 | mA |
| $I_{CC(1)}$ | Logical 1 level supply current | 6 | $V_{CC}$ = MAX, $V_{in}$ = 0 | | | 4 | 8 | mA |

## switching characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C, N = 10

| PARAMETER | | TEST FIGURE | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $t_{pd0}$ | Propagation delay time to logical 0 level | 65 | $C_L$ = 15 pF, $R_L$ = 400 Ω | | 7 | 15 | ns |
| $t_{pd1}$ | Propagation delay time to logical 1 level | 66 | $C_L$ = 15 pF, $R_L$ = 400 Ω | | 11 | 22 | ns |

[†] For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable device type.

[‡] All typical values are at $V_{CC}$ = 5 V, $T_A$ = 25°C.

[§] Not more than one output should be shorted at a time.

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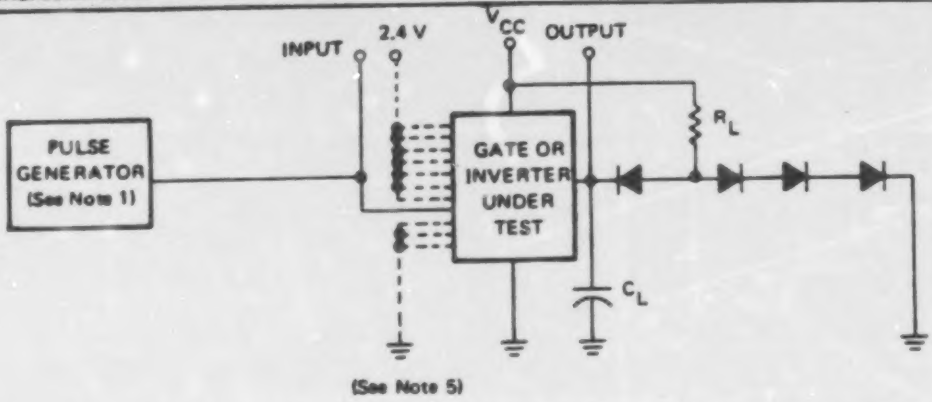
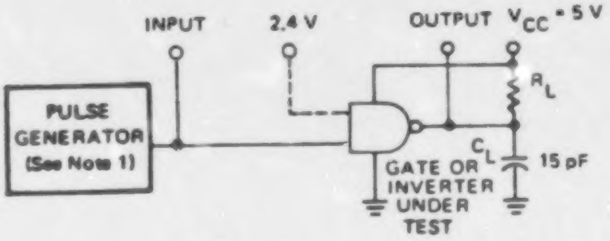
## PARAMETER MEASUREMENT INFORMATION

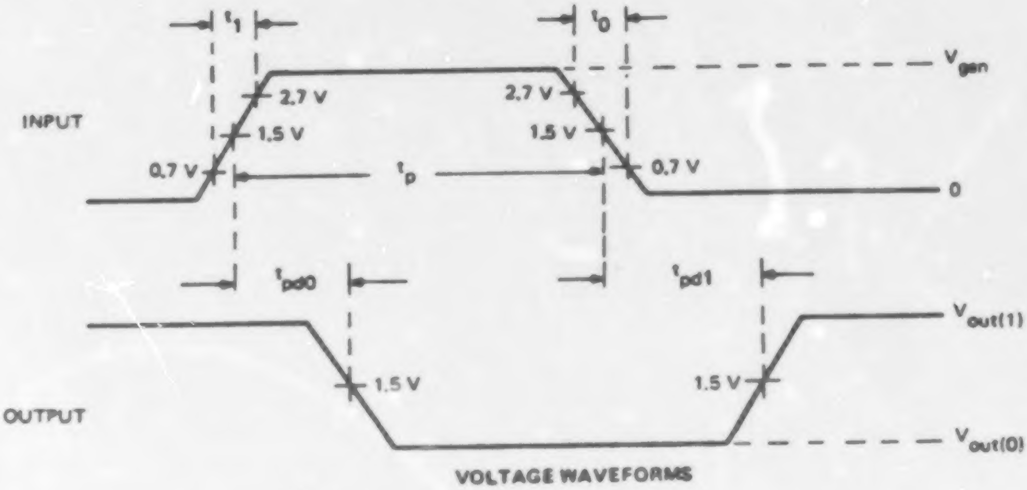
### switching characteristics


INPUT
2.4 V
$V_{CC}$
OUTPUT
PULSE GENERATOR (See Note 1)
GATE OR INVERTER UNDER TEST
$R_L$
$C_L$
(See Note 5)

TEST CIRCUIT FOR SN5400, SN5402, SN5404, SN5410, SN5420, SN5430, SN5440, SN5450, SN5451, SN5453, SN5454, SN7400, SN7402, SN7404, SN7410, SN7420, SN7430, SN7440, SN7450, SN7451, SN7453, AND SN7454


INPUT
2.4 V
OUTPUT
$V_{CC} = 5$ V
PULSE GENERATOR (See Note 1)
$R_L$
$C_L$
15 pF
GATE OR INVERTER UNDER TEST

TEST CIRCUIT FOR SN5401, SN5403, SN5405, SN7401, SN7403, SN7405


$t_1$
$t_0$
$V_{gen}$
INPUT
2.7 V
1.5 V
0.7 V
$t_p$
0
$t_{pd0}$
$t_{pd1}$
$V_{out(1)}$
1.5 V
OUTPUT
$V_{out(0)}$

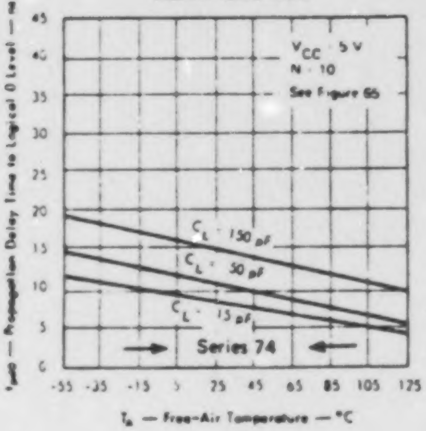
VOLTAGE WAVEFORMS

NOTES:
1. The generator has the following characteristic: $V_{gen} = 3.5$ V, $t_0 = 5$ ns, $t_1 = 10$ ns, $t_p = 0.5$ µs, PRR = 1 MHz, $Z_{out} \approx 50\ \Omega$.
2. All diodes are 1N3064.
3. $t_{pd} = \dfrac{t_{pd0} + t_{pd1}}{2}$
4. $C_L$ includes probe and jig capacitance.
5. When testing the SN5400/SN7400 through SN5440/SN7440 (except SN5402/SN7402) connect all unused inputs to 2.4 V. When testing the SN5402/SN7402 or SN5450/SN7450 through SN5454/SN7454, apply the input pulse to one input of one AND section and 2.4 V to all unused inputs of that AND section. All inputs of unused AND sections are grounded.

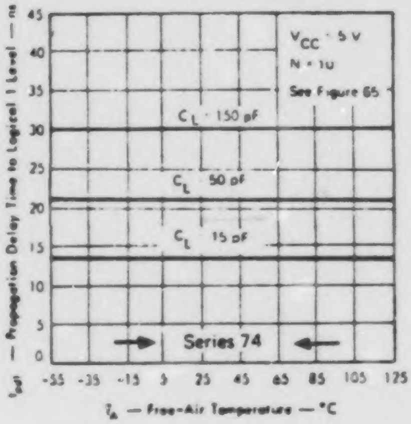
FIGURE 65-GATE PROPAGATION DELAY TIMES

## TYPICAL CHARACTERISTICS §

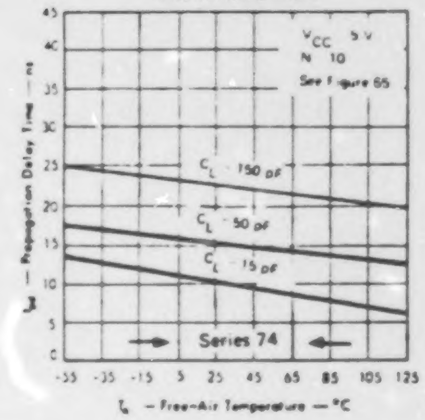
PROPAGATION DELAY TIME TO LOGICAL 0 LEVEL
vs
FREE-AIR TEMPERATURE



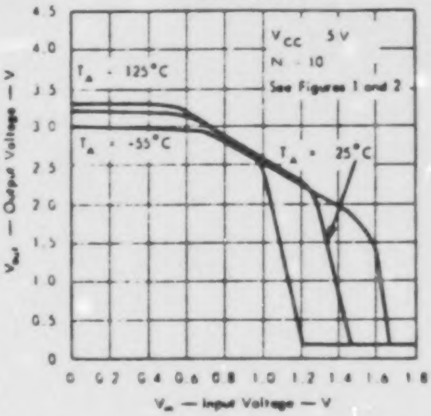
PROPAGATION DELAY TIME TO LOGICAL 1 LEVEL
vs
FREE-AIR TEMPERATURE



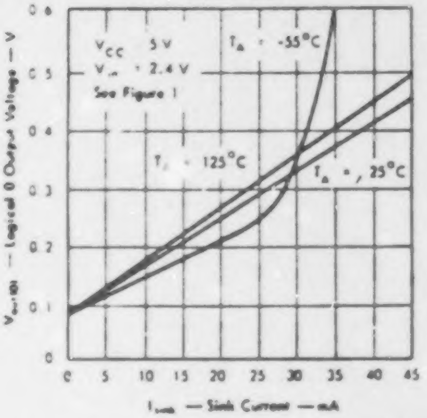
PROPAGATION DELAY TIME
vs
FREE-AIR TEMPERATURE



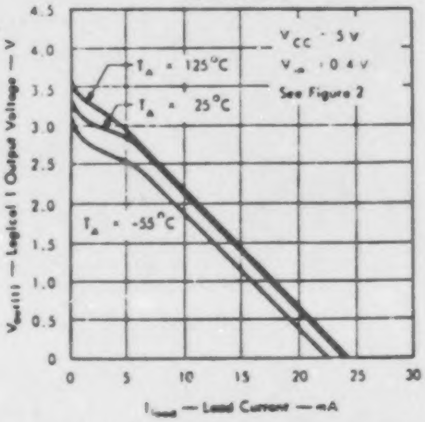
OUTPUT VOLTAGE
vs
INPUT VOLTAGE



LOGICAL 0 OUTPUT VOLTAGE
vs
SINK CURRENT



LOGICAL 1 OUTPUT VOLTAGE
vs
LOAD CURRENT



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§ Unless otherwise noted, data as shown is applicable for: SN5400, SN5402, SN5404, SN5410, SN5420, SN5430, SN5450, SN5451, SN5453, SN5454, SN7400, SN7402, SN7404, SN7410, SN7420, SN7430, SN7450, SN7451, SN7453, SN7454.

BEST COPY AV

ET 115
STUDY GUIDE
CHAPTERS 4, 5, 6
TEST #2

INFORMATION SHEET #3

Propagation delay is concerned with

At what percentage is propagation delay measured at

What are the percentages attributed to rise time

Determine the total propagation delay if individual gate delays are known

The advantages and disadvantages of high speed logic

Determine the noise immunity of a circuit, knowing the immunity rating and applied signal pulse voltage

Calculate the fan out of a typical TTL circuit loaded with an LED circuit

Identify LED TTL loads and simple transistor circuits as current sourcing or sinking

A fan out of _____ is equal to what load current

The type of manufacturing process that produces the most IC's

The definition of the monolithic manufacturing process

What the abbreviations LSI, SSI, and DIP stand for

The type of circuit integration that is the most basic of IC circuits

The typical minimum binary 1 TTL logic level and maximum binary 0 TTL logic level

The three tri-state logic levels are

The type of logic required for bi-directional data busses

The characteristics of low power TTL logic

The type of logic with the least propagation delay

The logic type that uses negative voltages for binary ones and zeros

What the CMOS disadvantages are

The logic type with the highest operating speed and the greatest power requirements

The type of transistors used in MOS and CMOS IC's

The type of logic with high noise immunity and low power requirements

Propagation delays are measured in

The Boolean expressions for AND, INV, OR AND NAND gates

Draw the symbols for an AND and NOR gate

Complete a NAND and OR gate Truth Table

Draw an AND gate using an OR gate and inverters

Draw a NOR gate using an AND gate and inverters

The number of bits a flip-flop stores

The binary states of a flip-flop

How the state of a flip-flop is determined

The flip-flop output when it is reset

The ambiguous state output

The type of flip-flop that is used in switch buffering

The fan out available from a latch circuit

The flip-flop that does not have an ambiguous state

What T, S, and C mean on a flip-flop

The conditions necessary for a J K flip-flop to toggle, latch and set

The number of flip-flops necessary to divide an input signal down to a specified frequency

The JK flip-flop a sychronous inputs

Match the Boolean Laws of Union, Tautology, Double Negative, Association, Intersection, Complements, Commutation and Distribution to a given mathmetical expression

ET 115
DIGITAL
CHAPTERS 1-3

TEST #1
95 Points

## GENERAL DIRECTIONS

This examination will be conducted from 5:20 pm to 7:20 pm. All papers must be turned in prior to 7:20 pm to receive credit for this test. The use of a calculator is permitted along with a list of approved formulas. (Note: formulas may not contain definition of terms.) Read the specific directions for Sections I and II as you reach those locations.

## SECTION I - MULTIPLE CHOICE (46 points)

Circle only the letter representing your choice of the most correct response. Mark only one response per question.

1. Binary refers to a signal that has:

    a. a single voltage state
    b. many voltage states
    c. two voltage states
    d. varying negative DC voltage

2. A NOR gate with inverters on all inputs becomes a:

    a. AND gate
    b. OR gate
    c. NOR gate
    d. NAND gate

3. The base of a transistor controls the:

    a. collector current
    b. emitter current
    c. both A & B
    d. neither A or B

4. A transistor has a $V_{CE}$ of 14 volts with a $V_{CC}$ of 14 volts. This device is:

    a. shorted
    b. operating linearly
    c. in saturation
    d. cut off

5. This circuit is a:

    a. AND gate
    b. NAND gate
    c. NOR gate
    d. OR gate

6. The amount of current flowing out of the collector compared to the amount of current flowing into the emitter in an NPN transistor is:

   a. less than the collector current
   b. equal to the collector current
   c. greater than the collector current
   d. equal to the emitter current

7. The device that is not digital is:

   a. TV channel selector
   b. SPST switch
   c. Simpson VOM
   d. hand-held calculator

8. A 1001 0110 1101 represents a:

   a. binary number
   b. BCD number
   c. excess 3 coded number
   d. gray coded

9. The increased use of digital techniques resulted primarily from:

   a. military electronic needs
   b. the desire to reduce costs
   c. the development of integrated circuits
   d. limitations of analog methods

10. A transistor output that placed in parallel with a load is known as:

   a. logic level
   b. shunt switch
   c. negative logic
   d. series switch

11. A NAND gate with an inverter on its output becomes a:

   a. AND gate
   b. OR gate
   c. NOR gate
   d. NAND gate

12. A transistor has a $I_B$ of 1 mA and $I_C$ of 22 mA with an $h_{FE}$ of 250. This device is:

   a. in saturation
   b. operating linearly
   c. cut-off
   d. defective

13. An OR gate will produce a binary 1 output when:

    a. all inputs are 1
    b. all inputs are 0
    c. any single input is a 1
    d. either A or C

14. A transistor has the EB junction forward biased and the CB junction reversed biased. The device is:

    a. shorted
    b. cut-off
    c. operating linearly
    d. in saturation

15. The anode of a PN diode is made up of:

    a. cathode material
    b. N type material
    c. P type material
    d. material a majority of free electrons

16. A binary word that is five bits will have:

    a. five ones
    b. five zeros
    c. 2 ones and 3 zeros
    d. any of the above

17. The output algebraic expression $C = \overline{A \bullet B}$ is for a:

    a. AND gate
    b. OR gate
    c. NAND gate
    d. NOR gate

18. A bipolar transistor can be operated in which mode of operation:

    a. cut-off
    b. linear
    c. saturation
    d. any of the above

19. The majority of current flow in a transistor occurs through the:

    a. emitter base region
    b. collector base region
    c. collector emitter region
    d. ground base region

20. A flip-flop is used as a:

    a. gate
    b. decision making circuit
    c. negative logic element
    d. memory element

21. Five SPST switches in parallel are the equivalent of a:

    a. AND gate
    b. NOR gate
    c. NAND gate
    d. none of the above

22. An advantage of the BCD code is:

    a. the code combinations can be easily remembered
    b. it simplifies arithmetic computations
    c. made up of a 4 & 3 bit group
    d. any of the above

23. Which one of the following is not a decision making logic element:

    a. OR gate
    b. AND gate
    c. inverter
    d. flip-flop

24. A P type semiconductor material has a/an:

    a. excess of holes
    b. excess of free electrons
    c. electrons as majority current carriers
    d. conductivity greater than copper

25. The number $100_2$ is a:

    a. decimal number
    b. binary number
    c. octal number
    d. number equal to 8

26. An advantage of serial data transmission is:

    a. it is faster than parallel
    b. it is slower than parallel
    c. it requies multiple transmission lines
    d. it requires only transmission line

27. In BCD, the code 1011 is:

    a. 11
    b. the letter B
    c. 23
    d. invalid

28. The output algebraic expression C = A + B is for a:

    a. AND gate
    b. OR gate
    c. NAND gate
    d. NOR gate

29. A transistor has both the EB and CB junctions forward biased. The device is:

    a. open
    b. in saturation
    c. cut-off
    d. operating linearly

30. Emitter-collector resistance will increase with a:

    a. increase in base current
    b. decrease in base current
    c. increase in emitter current
    d. none of the above

31. A PN diode that is conducting is said to be:

    a. forward biased
    b. reversed biased
    c. made up of N type material
    d. an open circuit

32. A 4 bit BCD number can represent a decimal number that is:

    a. greater than 16
    b. less than 1
    c. no greater than 10
    d. no larger than 15

33. A transistor has a CE voltage of .25 volts with a $V_{CC}$ of 12 volts. The transistor is:

    a. open
    b. cut-off
    c. saturated
    d. operating linearly

34. An AND gate will produce a binary 1 output when:

    a. all inputs are 1
    b. all inputs [illegible] 0
    c. any single input is a 1
    d. any single input is a 0

35. Decision making logic circuits can be:

    a. AND gates
    b. OR gates
    c. NOR gates
    d. any of the above

36. The best BCD code for arithmetic operations is the:

    a. ASCII code
    b. pure BCD code
    c. gray code
    d. excess 3 code

37. The current carriers in a PNP transistor are:

    a. electrons
    b. holes
    c. majority carriers
    d. minority carriers

38. The simplest of digital logic circuit forms is the:

    a. inverter
    b. AND gate
    c. OR gate
    d. flip-flop

39. Three SPST switches in series is the equivalent of a:

    a. AND gate
    b. OR gate
    c. NOR gate
    d. NAND gate

40. If the cathode is made positive with respect to a diode's anode, the diode is:

    a. forward biased
    b. conducting
    c. reversed biased
    d. turned on by excess electron flow

41. The code which is used to minimize timing and speed errors in the:

    a. gray code
    b. ASCII code
    c. excess 3 code
    d. pure BCD code

42. A transistor has both the EB and CB junctions reversed biased. The transistor is:

    a. shorted
    b. cut-off
    c. in saturation
    d. operating linearly

43. A changing voltage level that changes in discrete steps is an example of a/an:

    a. sine wave
    b. analog signal
    c. digital signal
    d. random AC voltage

44. A data bus process all the bits of an eight bit word simultaneously. This is known as:

    a. parallel data handling
    b. serial data handling
    c. negative logic handling
    d. positive data handling

45. A PNP transistor has:

    a. 1 PN junction
    b. 2 PN junctions
    c. 3 PN junctions
    d. 4 PN junctions

46. A NAND gate with inverters on all inputs becomes a:

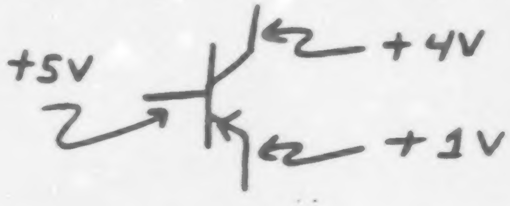
    a. AND gate
    b. OR gate
    c. NOR gate
    d. NAND gate

SECTION II - FILL IN (49 points)

47. The digital code for the best man to machine communications is ________________.

48. The type of gate that uses the expression C = A plus B plus C plus D is a __________________________ gate.

49. This transistor is operating in which region ____________________.



50. The maximum decimal number $2^{19}$ can represent is ________________.

51. The ratio of a transistor's collector to emitter current is known as the transistor's ____________________________________________.

52. The logic functions of these truth tables are: (3 points)
53.
54.

| A | B | C |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

______________

| A | B | C |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

______________

| A | B | C |
|---|---|---|
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

______________

C= output
A } Inputs
B }

55. A binary 0 is assigned a plus . 1volt. A binary 1 is assigned a plus 4.5 volts. This is considered to be ______________________ logic.

56. The type of gate that uses the expression $C = A^{o}B^{o}C^{o}D^{o}$ is a ______________________ gate.

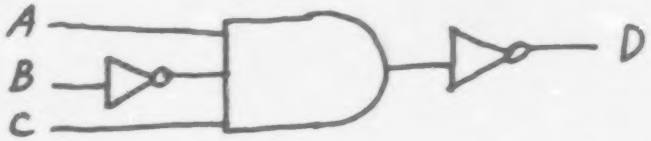
57. The digital code used for transmitting data between computers and their peripherals is _____________________________.

58. A binary 1011.010101 is equal to a decimal ____________________.

59. A binary 1100110001 is equal to a decimal ______________________.

60. The truth table for the below is: (3 points)
61.
62.

| A | B | C | D |
|---|---|---|---|
| 1 | 1 | 1 | |
| 1 | 1 | 0 | |
| 1 | 0 | 1 | |
| 1 | 0 | 0 | |
| 0 | 1 | 1 | |
| 0 | 1 | 0 | |
| 0 | 0 | 1 | |
| 0 | 0 | 0 | |



63. If a transistor's $h_{FE}$ is 87 and it's base current is 21$\mu$A, the collector current is ______________________.

64. ______________________ $A = B \circ C \circ D$

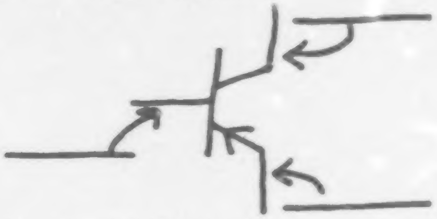
65. ______________________ $A = B + \overline{C} + D + E$

66. ______________________ $A = \overline{A \circ B \circ C}$

67. ______________________ $A = \overline{B}$

68. ______________________ $A = B + C$

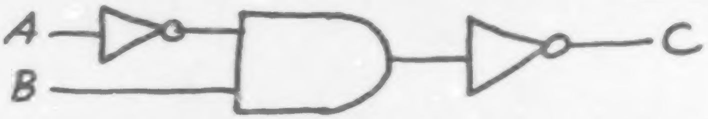
69. Using the voltages of plus 2, 4 and 12 volts properly bias the transistor for its linear region.



70. The number of bits it will take to represent a decimal 16388 is _____.

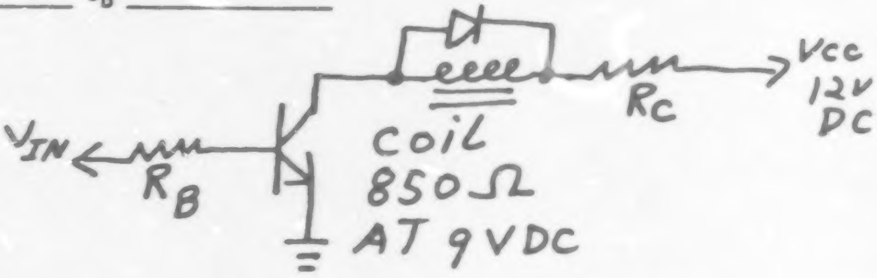
71. If the input to an inverter is a binary zero, the output will be a binary ______________.

72. The algebraic output equation for this circuit is ______________.



73. Design a common emitter saturated transistor switch. Determine the
74. values of the following: (8 points)
75.
76. $R_B$ ____________ $R_C$ ____________
77.
78. $I_C$ ____________ $I_B$ ____________
79.
80.

$h_{FE}$ = 50-175
$V_{CBO}$ = 30V
$V_{CO}$ = 25V
IC max = 150 mA
VCE sat - .3V
$V_{IN}$ - 2.6V

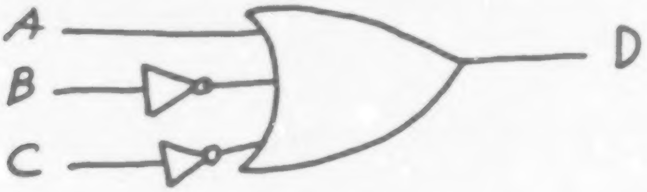


81. The ratio of a transistor's collector to base current is known as the transistor's ______________________________________________.

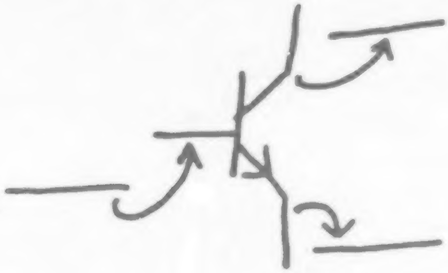
82. The abbreviation MSB stands for ____________________________________.

83. In a PNP transistor, the base must be more ___________________ than the emitter for forward bias (use negative or positive).

84. The output equation for this circuit is ___________________________.



85. Using the voltages of minus .2, 7 & 8 volts properly bias the transistor for linear operation.



86. The number of discrete binary states a 20 bit work represents is ____________________________________.

87. Digital circuits have many advantages over analog circuits in many
88. applications. List 3 of these advantages.
89.

a.

b.

c.

90. The voltage dropped across a silicon conducting PN function is ______.

91. A transistor has a $V_{CC}$ of 18 volts, a IC of 180 mA and a $V_{RC}$ of 16.25 volts the power dissipation of this device is: _______________.

92. The decimal number 92 is written in BCD as _________________________.

93. In a PNP device, the collector current is 10.8 mA. The emitter current is 12.7 mA. The base current is ____________________.

94. A decimal 182 is equal to a binary ____________________.

95. If an AND gate has 6 inputs, its total number of input combinations would be ____________________.

# ET 115
# DIGITAL
# CHAPTERS 4, 5, 6

TEST #2
71 Points

Name:______________________________________

GENERAL DIRECTIONS

The use of a calculator is permitted, along with a list of approved formulas. (Note: the formulas may not contain a definition of terms.) Read the specific directions for Sections I, II and III, as you reach those locations.

## SECTION I - MULTIPLE CHOICE (22 POINTS)

Circle only the letter representing your choice of the most correct response. Mark only one response per question.

1. The type of logic circuit that uses negative voltages for binary 1 or 0 values is:

   a. Schohtty TTL
   b. CMOS
   c. ECL
   d. Tri-State

2. To set the JK flip-flop, the JK inputs must be:

   a. J=0, K=0
   b. J=1, K=1
   c. J=1, K=0
   d. J=0, K=1

3. Gate propagation delays are measured in units of:

   a. seconds
   b. milliseconds
   c. microseconds
   d. nanoseconds

4. A signals rise time is the time it takes a square wave to:

   a. rise from 90 to 10% of its value
   b. fall from 90 to 10% of its value
   c. rise from 10 to 90% of its value
   d. fall from 10 to 90% of its value

5. A single digital flip-flop can store:

   a. one bit of data
   b. two bits of data
   c. three bits of data
   d. any number of data bits

6. The least expensive and the most basic of IC circuits is the:

   a. VLSI
   b. LSI
   c. SSI
   d. MIS

7. The TTL family with the least propagation delay is:

   a. standard TTL
   b. high power TTL
   c. low power TTL
   d. schottky TTL

8. The JK flip-flop asychronous inputs are:

   a. S & C
   b. J & K
   c. Q & Q
   d. T

9. In MOS and CMOS IC's, the type of transistor used in these circuits is the:

   a. enhancement mode MOSFET
   b. depletion mode JFET
   c. enhancement mode JFET
   d. BJT

10. High speed logic circuits vs low speed logic circuits:

    a. use nonsaturating logic
    b. have low $V_{EC}$ drops
    c. consume more power
    d. all of the above

11. The logic family with the highest operating speed is:

    a. CMOS
    b. TTL
    c. MOS
    d. ECL

12. The majority of IC's are manufactured using the:

    a. thin film process
    b. monolithic process
    c. hybrid process
    d. thick film process

13. Low power TTL logic has:
    a. higher values of internal resistances
    b. greater propagation delay
    c. high speed
    d. both a. & b.

14. In a JK flip-flop if both JK inputs are a binary zero and a clock pulse is applied, the device is:
    a. latched
    b. set
    c. reset
    d. toggles

15. The logic family with the highest power dissipation in millawatts per gate is:
    a. high power TTL
    b. ECL
    c. CMOS
    d. schottky TTL

16. The propagation delay of a square wave is measured at what point on the signal:
    a. 10%
    b. 20%
    c. 50%
    d. 90%

17. For determining the state the flip-flop is in, we must look at the devices:
    a. inputs
    b. outputs
    c. clock
    d. preset line

18. In a JK flip-flop if both JK inputs are a binary one and a clock pulse is applied, the device is:
    a. latched
    b. set
    c. reset
    d. toggles

19. The type of flip-flop that does not have an ambiguous state is the:
    a. D
    b. latch
    c. JK
    d. none of the above

20. A flip-flop has two distant states a binary:

    a. one & one
    b. one & zero
    c. zero & zero
    d. both a. & c.

21. Propagation delay in a digital circuit concerns itself with:

    a. storage times
    b. delay times
    c. rise times
    d. all of the above

22. The latch type flip-flop is most commonly used in:

    a. JK flip-flops
    b. counters
    c. switch buffering
    d. AND gates

SECTION II FILL IN (41 POINTS)

Place your answer in the space provided.

23. Draw the equivalent of a NOR gate using an AND gate with inverters:

24. Integrated circuits are often referred to as SSI, MSI, LSI and VLSI. What does the abbreviation LSI stand for ____________________________

25. A circuit is required to operate on batteries and have high noise immunity in an electric environment. The logic family that would best fill these requiements is ________________.

26. In an ambiguous state, the output of the flip-flop would be ______________________.

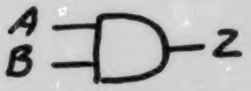
27. A major disadvantage of CMOS logic is ____________________________.

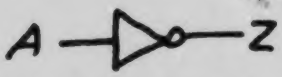
28. IC's come in a 16 pin DIP. What does the abbreviation DIP stand for ____________________________________________.

29. Draw the equivalent of an AND gate using an OR gate and inverters.

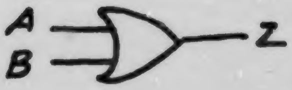
30. Four gates are connected in series with a propagation delay of 200nsec each. The total propagation delay for the circuit is ______________.

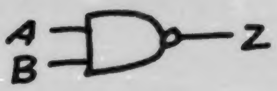
31. Identify each of the circuits as current sourcing or current sinking
32. (4 points)
33.
34.





__________________  __________________





__________________  __________________

35. The type of logic that has to be used in bi-directional data buss operations is ____________________________________.

36. The JK flip-flop often refers to its inputs and outputs as T, S, and
37. C. What do each of these stand for. (3 points)
38.

T ________________
S ________________
C ________________

39. AND gates are used in the construction of a latch. Each gate has a fan out of 10. The maximum usable fan out of this latch circuit is: ________________.

40. The binary one level for a digital IC is 4.5 volts DC. The circuit has a noise immunity rating of 30%. Noise pulses that are _______ volts or less will be rejected by the circuit

41. Draw the symbols for the following (2 points):
42.

3-Input NOR gate

2-Input AND gate

43. It is necessary to obtain a 762.9 $H_Z$ output from a 100 $MH_Z$ input
44. signal applied to a digital divider. If JK flip-flops were used, how
many single JK's are needed to complete the circuit requirements:
__________________. (2 points)

45. A typical TTL logic gate would have a minimum binary one level of
46. ________________________ volts and a maximum binary zero level of
__________ volts. (2 points)

47. If a flip-flop is reset, its Q output is a binary ___________.

48. An integrated circuit that is constructed entirely on a single
substrate of silicon uses the ____________________ manufacturing
method.

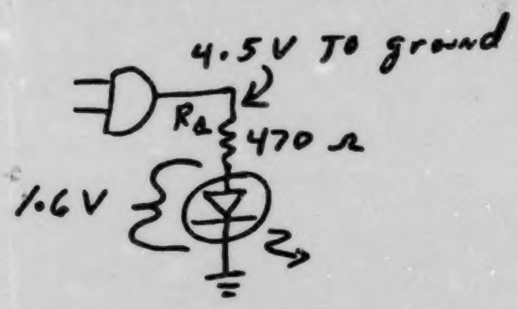
49. Complete the truth tables (4 points):
50.
51.
52. **NAND GATE**

| Inputs | | Output |
|---|---|---|
| A | B | Z |
| 0 | 0 | |
| 0 | 0 | |
| 0 | 1 | |
| 1 | 1 | |

**OR GATE**

| Inputs | | Output |
|---|---|---|
| A | B | Z |
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |

53. An LED is connected to a TTL logic gate as shown. Using a fan out of
54. ten, calculate the available fan out still remaining after the LED
55. load is connected. (4 points)
56.

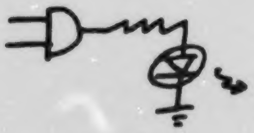


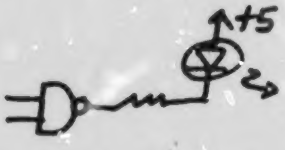
Remaining fanout = ___________

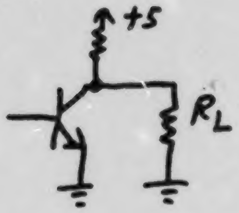
$I_{R_1}$ = _______________

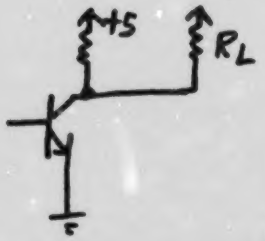
57. The three states of tri-state logic are: ______________________
58.
59. ______________________ ___________________________ (3 points)

60. Write the Boolean algebra expression for the gates. Do not reduce the
61. expressions. (4 points)
62.
63.









## SECTION III MATCHING (8 POINTS)

Match the Boolean Algebra Rule with the correct mathmatical expression:

64. ______ Law of Tautology
65. ______ Law of Double Negative
66. ______ Law of Intersection
67. ______ Law of Commutation
68. ______ Law of Distribution
69. ______ Law of Complements
70. ______ Law of Association
71. ______ Law of Union

(1) A = A
(2) B+0 = B
(3) AB+AC = A(B+C)
(4) A+(B+C) = A+B+C
(5) A 1 = A
(6) A A = 0
(7) B+B = B
(8) A+B = B+A
(9) A B = A+B

ET 115
Digital
BIPOLAR SWITCH

Lab #1
58 points

Name(s) ____________________

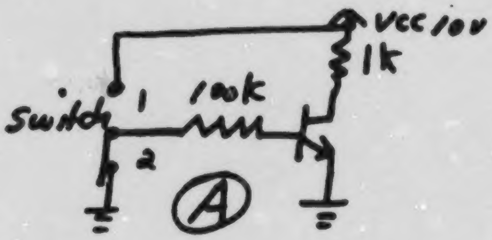
____________________

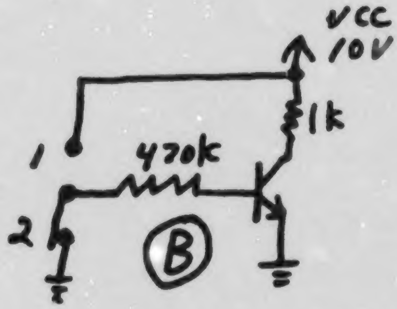
**OBJECTIVE:** To determine the voltage characteristics of a bipolar transistor that is operated in its linear and saturated regions.

**MATERIALS:** 2N3391 Transistor NPN, 1k ohm, 100k ohm and 470k ohm resistors.

**EQUIPMENT.** Power Supply, proto board and DMM.

**CIRCUIT:**





**PROCEDURE:** Construct circuit "A" as indicated. The pinouts from the device are E C B with the leads pointing towards your eye and with the flat surface towards the ceiling. Apply the indicated voltage with the switch in position 1. Record $V_C$ and $V_B$ with respect to ground.

4 points

| | $V_C$ | $V_B$ |
|---|---|---|
| pos 1 | | |
| 2 | | |

Place the switch in position 1 and record $V_{BE}$, $V_{CB}$ and $V_{CE}$ noting the polarity of each voltage.

3 points

| $V_{BE}$ | $V_{CB}$ | $V_{CE}$ |
|---|---|---|
| | | |

10 points From the measured data determine if the transistor is saturated, is not saturated and the reason for its conditions.

4 points Construct circuit "B". Record $V_C$ and $V_B$ with switch in positions 1 and 2 referenced to ground.

| | $V_C$ | $V_B$ |
|---|---|---|
| pos 1 | | |
| 2 | | |

Place the switch in position 1 and record $V_{BE}$, $V_{CB}$ and $V_{CE}$ noting the polarity of each voltage.

3 points

| $V_{BE}$ | $V_{CB}$ | $V_{CE}$ |
|---|---|---|
| | | |

From the measured data determine the condition of the transistor (linear or saturated) and the reason either case is true.

10 points

Using circuit "B" with switch in position 1 record the voltage values of these resistors to obtain an accurate result. Calculate the current through each resistor and record. Also calculate the Beta of that transistor.

7 points

| | |
|---|---|
| $R_C$ | |
| $R_B$ | |
| $V_{RC}$ | |
| $V_{RB}$ | |
| $I_C$ | |
| $I_B$ | |
| $I_C/I_B$ | |

Repeat the above using circuit "A" with the switch in position 1.

7 points

| | |
|---|---|
| $R_C$ | |
| $R_B$ | |
| $V_{RC}$ | |
| $V_{RB}$ | |
| $I_C$ | |
| $I_B$ | |
| $I_C/I_B$ | |

Compare the Beta of circuit "A" and "B". Is it possible to determine which transistor is saturated by comparing the Beta? Explain.

10 points

Et 115
Digital
REAL WORLD CIRCUITS

Lab #2
75 points

Name(s) ______________________________

______________________________

OBJECTIVE: To design a simple common emitter saturated transistor lamp and relay driver circuit.

EQUIPMENT: Power supply, Proto-board, VOM, and DMM

MATERIALS: Resistors, Transistor, Relay, LED, and dioe

TRANSISTOR: 2N4124, Silicon, NPN, HSA, $P_D$ 310 mW, $V_{CBO}$ 30 Volts, $V_{CE}$ 25 volts, $I_{C\ max}$ 200 mA, $h_{FE}$ 120-360, and $V_{CE\ sat}$ .3 volts at 50 mA.

PROCEDURE: Design two circuits; one a lamp driver and the other a relay driver. In both cases, the electrical characteristics of the relay and the LED are unknown. Determine this unknown data before proceeding. On an attached sheet describe the procedures used to find
20 points the unknown data, without damaging the components.

Once this data is known, calculate the unknown resistance values using a power supply voltage of 18 volts for the relay circuit and
15 points 12 volts for the LED. Show all calculations on an attached sheet.

Use a $V_{in}$ for the relay of 4.5 volts and 8 volts for the LED. Use a simple two resistor voltage divider to achieve the required $V_{in}$ for the given power supply voltages. Show all calculation on an
15 points attached sheet.

15 points Construct each circuit and measure the following.

| | RELAY | LED |
|---|---|---|
| $V_{CC}$ | | |
| $R_C$ | | |
| $R_B$ | | |
| $E_{RC}$ | | |
| $E_{RB}$ | | |
| $I_C$ | | |
| $I_B$ | | |
| $h_{FE}$ | | |

| | | |
|---|---|---|
| $R_{R1}$ | ______ | ______ |
| $R_{R2}$ | ______ | ______ |
| $E_{R1}$ divider | ______ *ON | ______ *ON |
| $E_{R2}$ divider | ______ ON | ______ ON |
| $E_{R1}$ divider | ______ OFF | ______ OFF |
| $E_{R2}$ divider | ______ OFF | ______ OFF |
| I divider | ______ | ______ |

10 points Draw a diagram in the space below, showing all parts values, voltages and currents for each circuit.

*Transistor is biased on or off. Make voltage divider measurements under both conditions, i.e., divider is loaded or unloaded.

ET 115
Digital
LOGIC INVERTER

Lab #3
40 points

Name(s) ______________________________

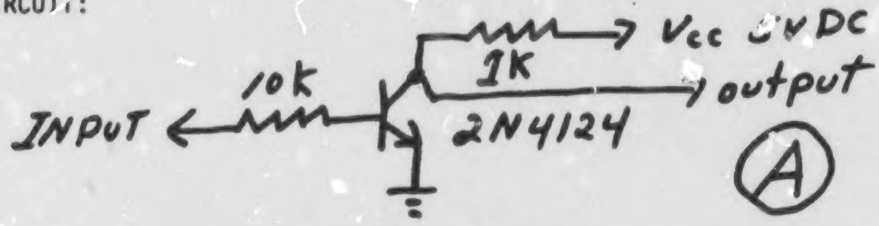
______________________________

**OBJECTIVE:** To demonstrate the operation of a discrete component and IC logic inverters.

**MATERIALS:** 2-LED's, 2-10k ohm, 2-470 ohm and 2-1k ohm resistors, 2-2N4124 Transistors, 1-SN7404 TTL hex inverter.

**EQUIPMENT:** Power supply, VOM, DMM, Function Generator, Proto-board

**CIRCUIT:**



**PROCEDURE:** Construct circuit "A". Apply a binary 1 and 0 to the input and record the output and input voltages with respect to ground. Use a plus five for a binary one and ground for a binary zero. Once the voltages are recorded, convert the voltages into binary 1's and 0's. Use the fixed 5 volt power supply output only for $V_{CC}$.

8 points

| $V_{in}$ | $V_{out}$ | Binary In | Binary Out |
|---|---|---|---|
| | | | |
| | | | |

Connect the TTL output of the function generator to the input of the gate. (Note: The 10k resistor must remain in the circuit) Set the generator to 1 Hz and observe with a VOM the input vs output voltages.

**CIRCUIT:**

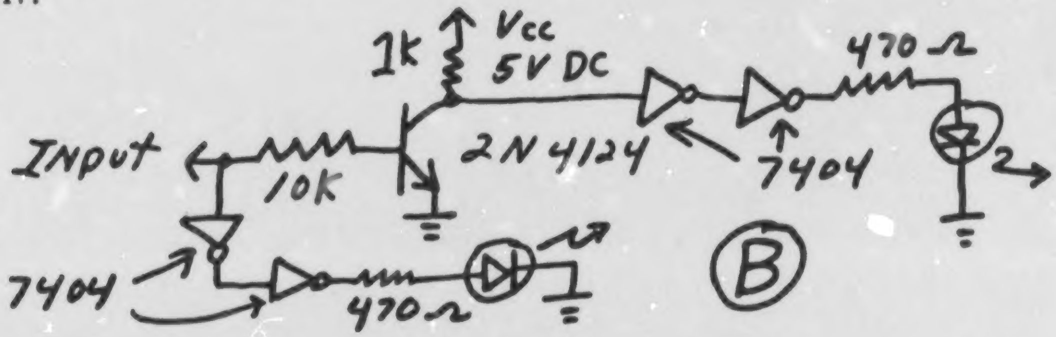
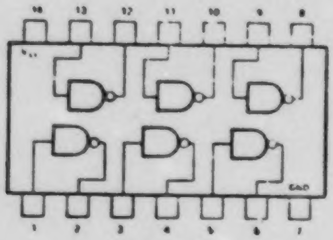


DIAGRAM: Use the following pin-out diagram for circuit "B". Be sure to connect power to pin #14 ($V_{CC}$) and ground to pin #7 or the IC will not function.


14
13
12
11
10
9
8
Vcc
GND
1
2
3
4
5
6
7

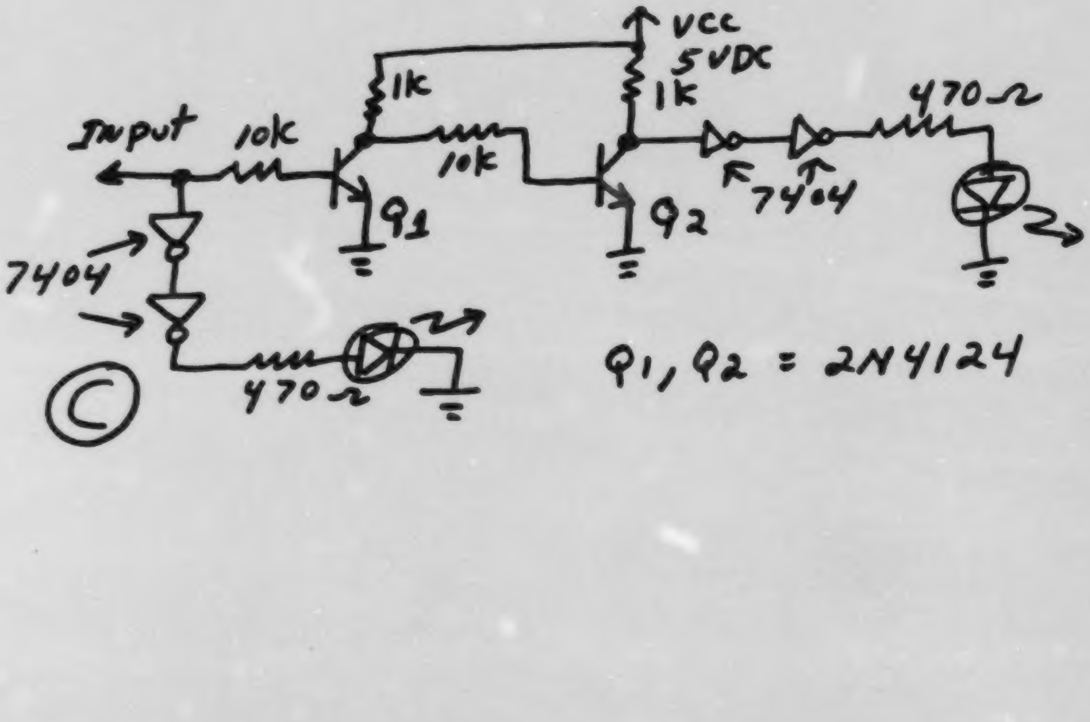
PROCEDURE: Construct Circuit "B". Apply a logic one and a logic zero to the input and observe the LED's. Record an ON or OFF below to show LED condition.

4 points

| Input | Input LED | Output LED |
|---|---|---|
| 1 | | |
| 0 | | |

Reconnect the function generator and observe the LED action as the frequency is varied.

CIRCUIT:


VCC
5VDC
1k
1k
470Ω
Input
10k
10k
Q1
Q2
7404
7404
470Ω
Q1, Q2 = 2N4124
C

PROCEDURE: Construct circuit "C". Apply a logic one and a logic zero to the input and record the LED's condition. (ON or OFF)

4 points

| Input | Input LED | Output LED |
|---|---|---|
| 1 | | |
| 0 | | |

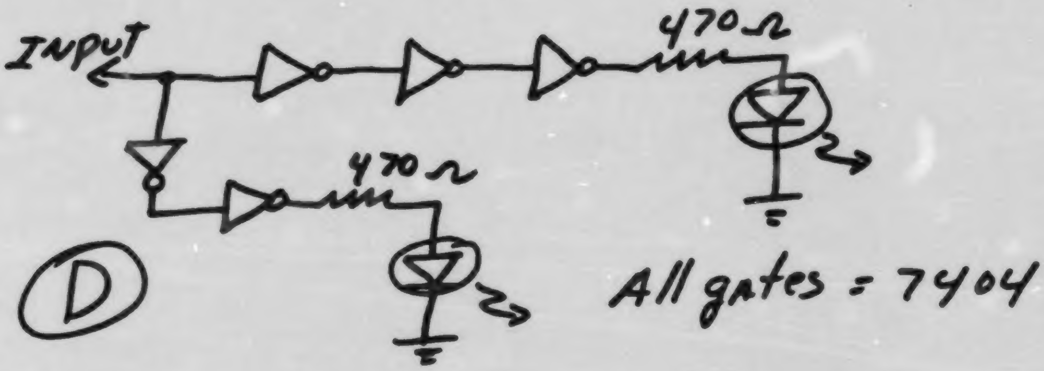
20 points

Analyze circuit "C" in terms of transistor operation and 7400 gate operation, i.e., tell me what is happening and why.

PROCEDURE: Construct circuit "D". Observe the LED output, input and record. (On or OFF)

4 points

| Input | Input LED | Output LED |
|---|---|---|
| 1 | | |
| 0 | | |



ET 115
Digital
DIODE LOGIC GATE

Lab #4
32 points

Name(s) ______________________

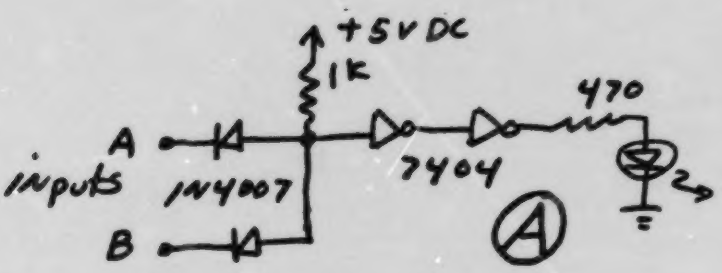
______________________

**OBJECTIVE:** To observe the operation and characteristics of a diode logic gate.

**MATERIALS:** Two 1N4007 diodes, 1k ohm, 2-470 ohm resistors, two LED's, SN7404 hex inverter

**EQUIPMENT:** Power supply, Proto-board, Function generator

**CIRCUIT**



SN7404 Pin-Out

**PROCEDURE:** Construct circuit "A". Apply a binary 1 and 0 to the inputs following the truth table. Use a plus five volts for a binary one and ground for a binary zero. Record the outputs in the provided truth table along with the algebraic output equation and the designation as to gate type.

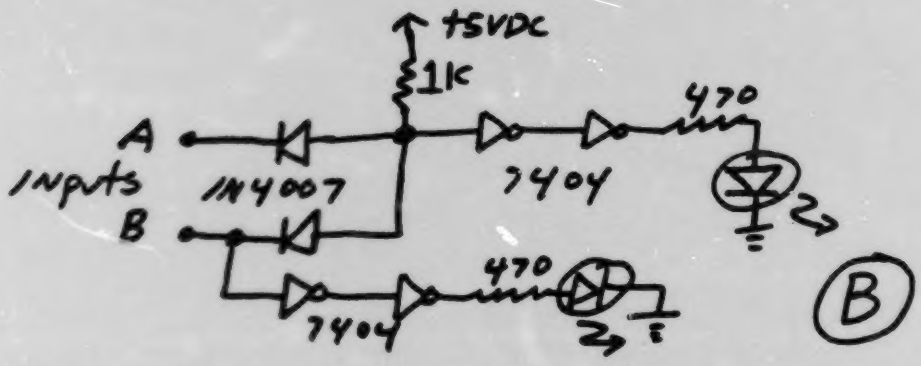
| A | B | C |
|---|---|---|
| 1 | 1 | |
| 1 | 0 | |
| 0 | 1 | |
| 0 | 0 | |

6 points

______________________
Gate type

______________________
Output equation

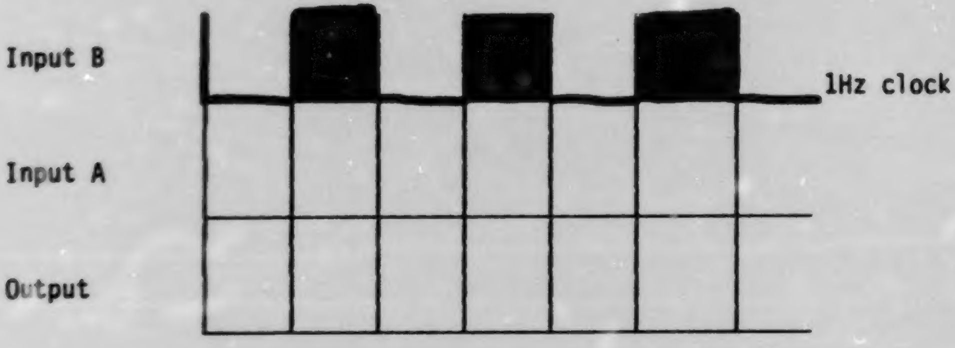
CIRCUIT:


+5VDC
1K
A
Inputs
B
1N4007
7404
470
7404
470
B

PROCEDURE: Construct circuit "B". Apply a 1Hz TTL signal from the function generator to input B. Apply a binary one and then a binary zero to input A. Describe the effect the change in input A had on the circuit output.

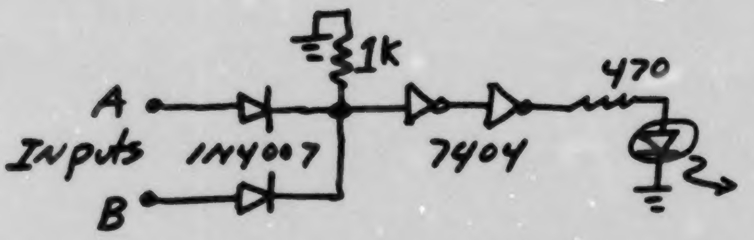
5 points

PROCEDURE: Complete the timing diagram indicating the effect the change in input A's condition had on the circuit output. Apply a high (1) to input A for a period of one clock cycle and a low (0) for one clock cycle.


Input B
1Hz clock
Input A
Output

5 points

CIRCUIT:


1K
470
A
Inputs
1N4007
7404
B

Ⓒ

PROCEDURE: Construct circuit "C". Apply a binary 1 and 0 to the inputs following the truth table. Record the outputs along with the output equation and the gate type designation.

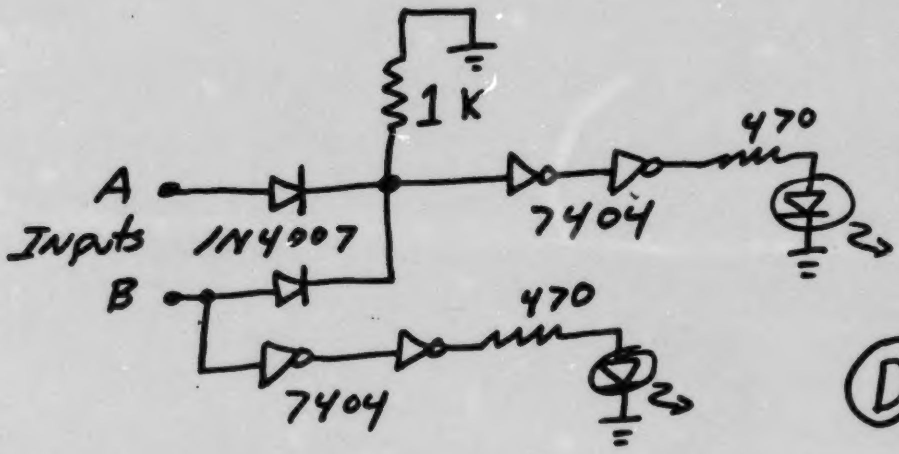
| A | B | C |
|---|---|---|
| 1 | 1 | |
| 1 | 0 | |
| 0 | 1 | |
| 0 | 0 | |

Gate type

Output equation

6 points

CIRCUIT:

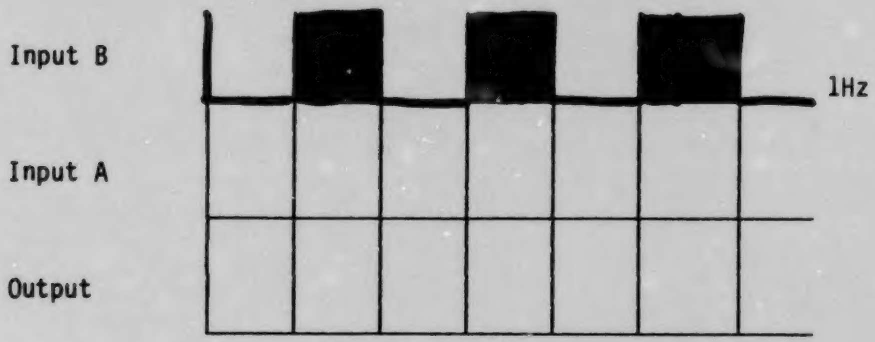

1K
470
A
Inputs
1N4007
7404
B
470
7404

Ⓓ

PROCEDURE: Construct circuit "D". Apply a 1Hz TTL signal to input B. Apply a binary one and then a binary zero to input A. Describe the effect the change in input A had on the circuit output.

5 points

PROCEDURE: Complete the timing diagram indicating the effect the change in input A's condition had on circuit output. Apply a high (1) to input A for a period of one clock cycle and a low (0) for one clock cycle.



5 points

ET 115
Digital
TRANSISTOR GATE

Lab #5
24 points

Name(s) ______________________

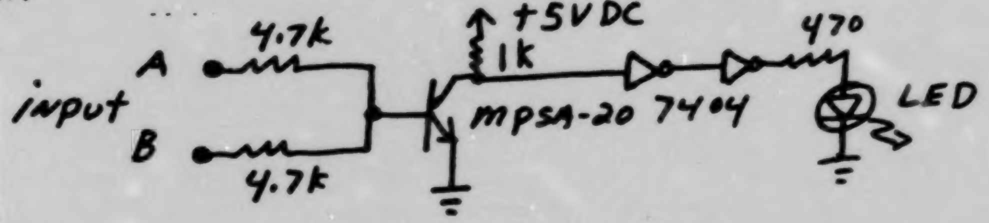
______________________

**OBJECTIVE:** To observe the operation of an RTL (Resistor Transistor Logic) logic gate.

**MATERIALS:** MPSA-20 transistor (417-801), 1k ohm, 470 ohm, two 4.7k ohm resistors, SN7404, IC, LED

**EQUIPMENT:** Power supply, Proto-board, DMM

**CIRCUIT:**



**PROCEDURE:** Construct the above circuit. Apply a binary one and zero to the inputs using the provided truth table. Observe the outputs and record.

| A | B | Output |
|---|---|---|
| 1 | 1 | |
| 1 | 0 | |
| 0 | 1 | |
| 0 | 0 | |

12 points

The Boolean algebra expression for this gate is ______________.
This gate is a __________ gate.

**PROCEDURE:** Using the same circuit, tie both of the inputs together. Generate the approrpiate truth table along with the Boolean algebra expression and the gate type.

12 points

ET 115
Digital
TTL NAND GATE

Lab #6
74 points

Name(s) ____________________

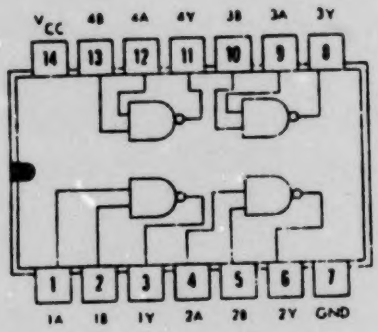
____________________

OBJECTIVE: To construct three varieties of logic gates from a NAND gate and to observe the output and input characteristics of loaded and unloaded gates.

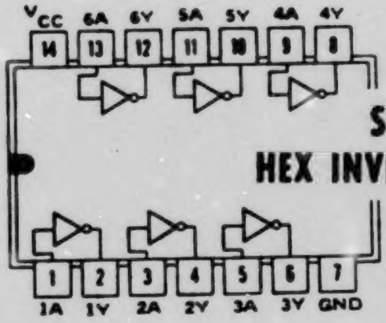
MATERIALS: SN7400 IC, three LED's, 1N4149 silicon diode (56-56), SN7404 IC, five 470 ohm resistors

EQUIPMENT: Power supply - Proto-board, DMM

PIN-OUTS:

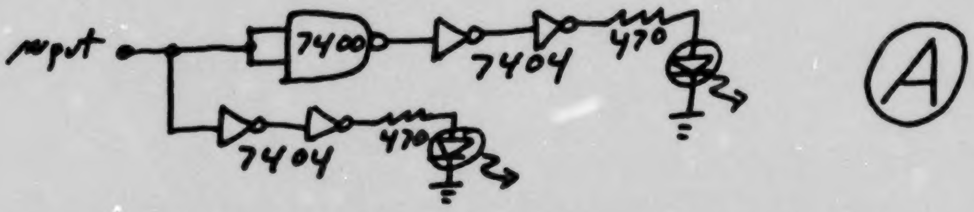

V<sub></sub>CC
4B
4A
4Y
3B
3A
3Y
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1A
1B
1Y
2A
2B
2Y
GND

**SN7400**
**NAND GATES**


VCC
6A
6Y
5A
5Y
4A
4Y
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1A
1Y
2A
2Y
3A
3Y
GND

**SN7404**
**HEX INVERTERS**

CIRCUIT:


input
7400
7404
470
7404
470
A

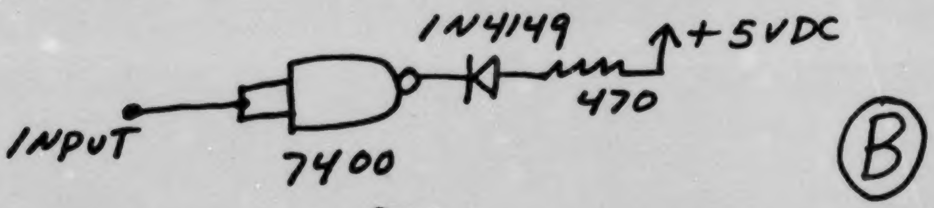
PROCEDURE: Connect the proper pins of both IC's to plus 5 volts and ground. Check the pin-out diagram for the correct connections.

Construct circuit "A". Place a binary one and zero on the input as indicated in the truth table. Record the output conditions along with the output and input voltages. Record these foltages at the output of the NAND gate and likewise the input voltages at the input of the NAND gate. Record a one or a zero in the output column to indicate the output state in relation to the input state.

6 points

| Input | Input voltage | output | output voltage |
|---|---|---|---|
| 1 | | | |
| 0 | | | |

CIRCUIT:

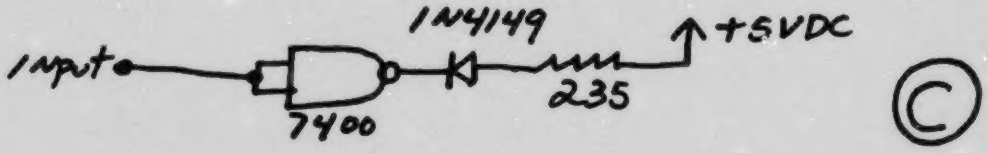

1N4149
+5VDC
470
INPUT
7400
B

PROCEDURE: Construct circuit "B". Place a binary one and zero on the inputs as indicated in the truth table and record the voltages at the input and output of the NAND gate.

| Input | Input voltage | Output | Output voltage |
|---|---|---|---|
| 1 | | | |
| 0 | | | |

6 points

CIRCUIT:



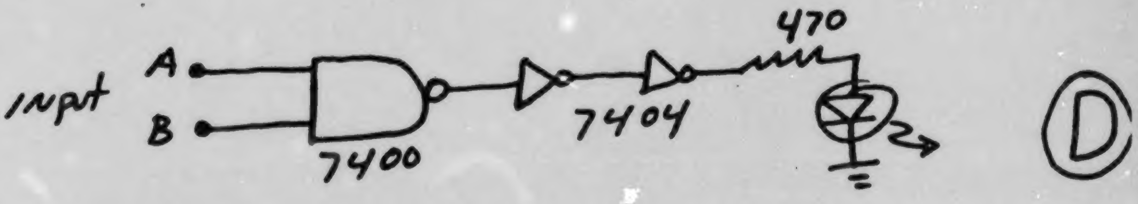
PROCEDURE: Construct circuit "C". Repeat the previous procedure recording input output voltages. Note: use two 470 ohm resistors in parallel for the 235 ohm resistor.

6 points

PROCEDURE: Compare the input and output voltages of the three previously constructed circuits. State your reasons why the voltages varied as they did. Justify your response by analyzing the circuit load in relation to either a current sink or current supply load circuit scenario.

5 points

CIRCUIT:



PROCEDURE: Construct circuit"D". Place a binary one and zero on the inputs as indicated in the truth table. Observe the output and record. Note: in completing the Boolean expression and gate type, disregard the 7404 hex inverters. These devices are only used to provide logic level indications.

6 points.

| A | B | Output |
|---|---|---|
| 1 | 1 | |
| 1 | 0 | |
| 0 | 1 | |
| 0 | 0 | |

Boolean Expression ____________________

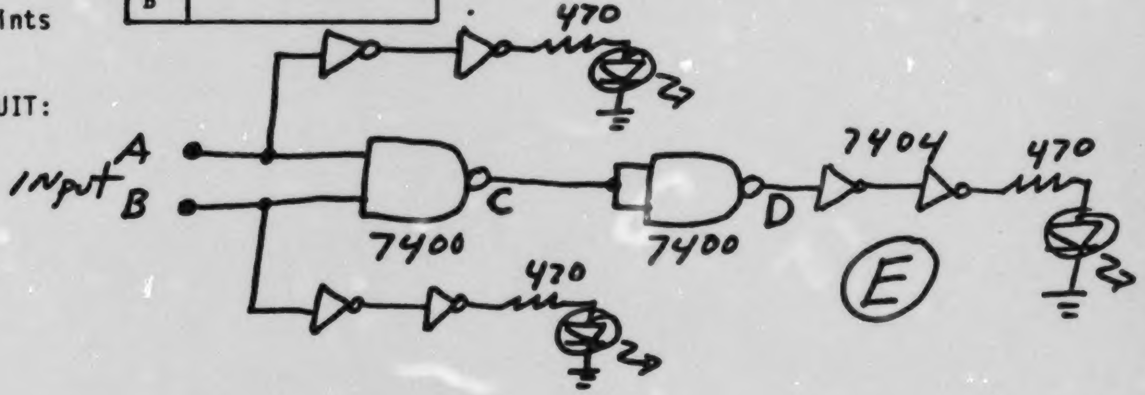
Gate Type ____________________

Remove all connections from the inputs of circuit "D". What is the output logic state under these conditions? ________
Measure the input voltage at each input with a DMM. Inputs must be floating.

| | Voltage |
|---|---|
| A | |
| B | |

3 points

CIRCUIT:



PROCEDURE: Construct circuit "E". Place a binary one and zero on the inputs as indicated in the truth table. Observe and record.

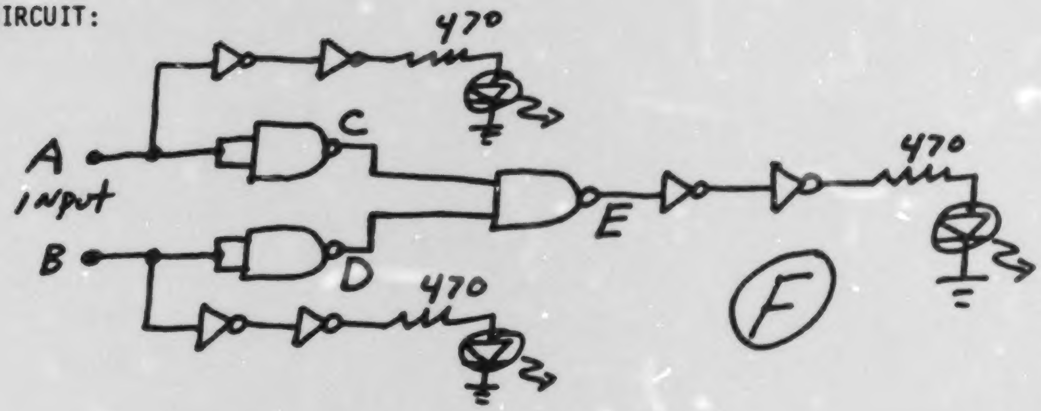
10 points

| A | B | C | D |
|---|---|---|---|
| 1 | 1 | | |
| 1 | 0 | | |
| 0 | 1 | | |
| 0 | 0 | | |

Boolean Expression ____________________

Gate Type ____________________

CIRCUIT:


470
C
A
input
E
470
B
D
470
F

PROCEDURE: Construct circuit "F". As in previous examples, complete the truth table.

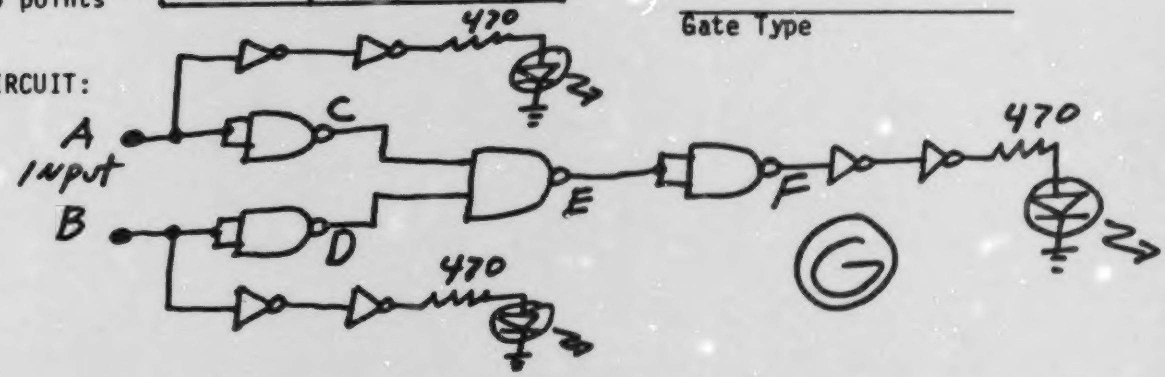
| A | B | C | D | E |
|---|---|---|---|---|
| 1 | 1 | | | |
| 1 | 0 | | | |
| 0 | 1 | | | |
| 0 | 0 | | | |

14 points

Boolean Expression

Gate Type

CIRCUIT:


470
C
A
input
E
F
470
B
D
G
470

PROCEDURE: Construct circuit "G". As in previous examples, complete the truth table.

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| 1 | 1 | | | | |
| 1 | 0 | | | | |
| 0 | 1 | | | | |
| 0 | 0 | | | | |

Boolean Expression

18 points

Gate Type

ET 115
Digital
# THE NAND AND NOR GATE

LAB #7
64 points

Name(s) ____________________

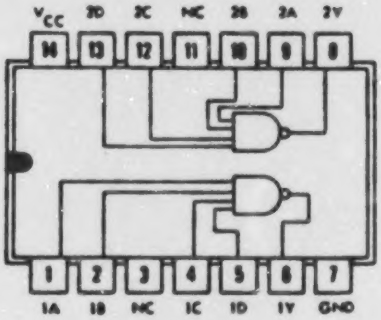
____________________

OBJECTIVE: To demonstrate the validity of Boolean algebra in simplifying gate design.

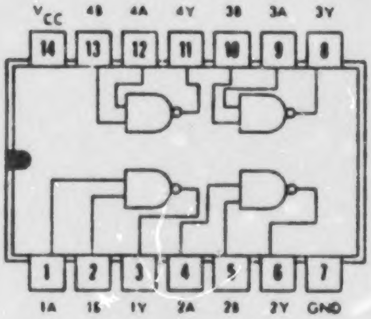
MATERIALS: SN7400 TTL two input NAND gate, SN7402 TTL two input NOR gate, SN7404 TTL Hex inverter, SN7420 TTL four input NAND gate, 470 ohm resistor, LED

EQUIPMENT: Power supply, proto-board

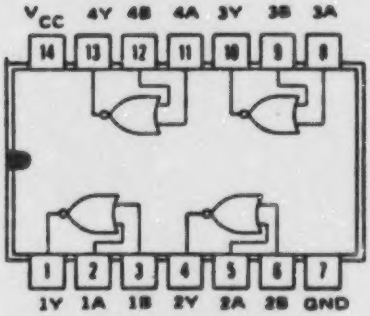
PIN-OUTS:


$V_{CC}$
2D
2C
NC
2B
2A
2Y
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1A
1B
NC
1C
1D
1Y
GND

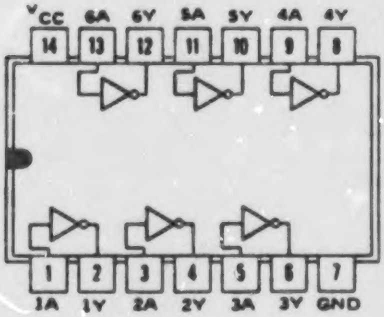
**SN7420**


$V_{CC}$
4B
4A
4Y
3B
3A
3Y
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1A
1B
1Y
2A
2B
2Y
GND

**SN7400**

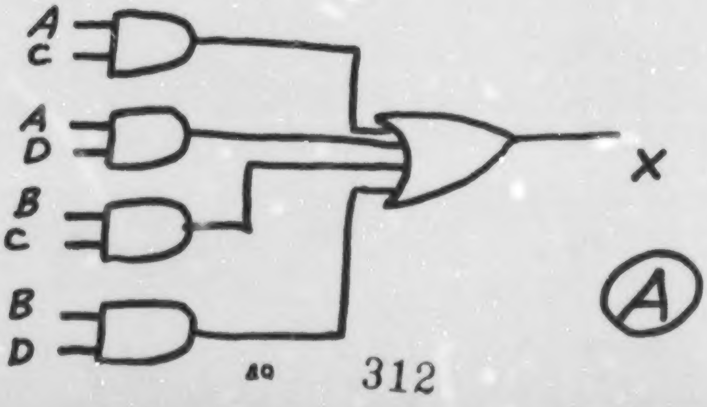

$V_{CC}$
4Y
4B
4A
3Y
3B
3A
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1Y
1A
1B
2Y
2A
2B
GND

**SN7402**

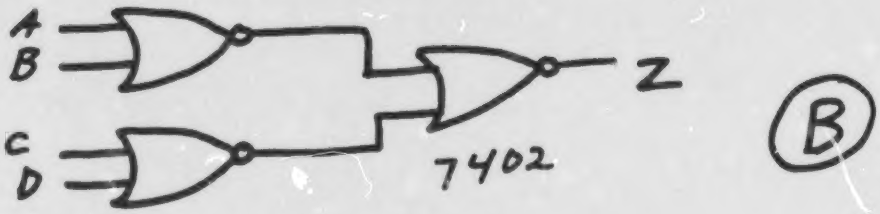

$V_{CC}$
6A
6Y
5A
5Y
4A
4Y
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1A
1Y
2A
2Y
3A
3Y
GND

**SN7404**

DIAGRAM:



CIRCUIT:



PROCEDURE: Construct Circuit "B". Add the LED output driver for one and zero indications and connect to point "Z". Using the previous truth table input ones and zeros recording the output in column "Z".

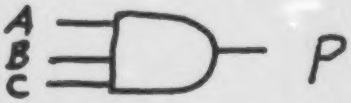
16 points

The Boolean algebra expression for gate circuit "B" is

2 points Z = ____________________

PROCEDURE: Complete the truth table for a three input AND gate. Do not build up this circuit.

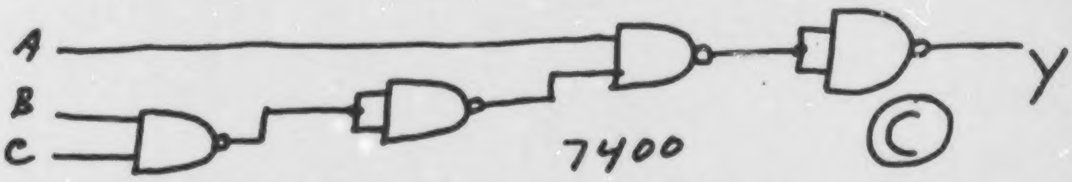
| INPUT | | | OUTPUT | |
|---|---|---|---|---|
| A | B | C | P | Y |
| 0 | 0 | 0 | | |
| 0 | 0 | 1 | | |
| 0 | 1 | 0 | | |
| 0 | 1 | 1 | | |
| 1 | 0 | 0 | | |
| 1 | 0 | 1 | | |
| 1 | 1 | 0 | | |
| 1 | 1 | 1 | | |



P = ABC

8 points

CIRCUIT:



PROCEDURE: Construct circuit "C" using a SN7400 IC. Use the LED output driver at output "Y" to indicate the output state. Apply a binary one and zero to the inputs as indicated in the truth table. Record in column "Y" in the previous truth table.

8 points

The Boolean algebra expression for gate circuit "C" is

2 points Y = ____________________

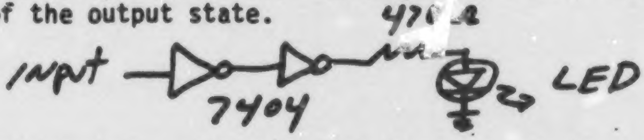
PROCEDURE: Determine the correct Boolean algebra expression for gate diagram "A". Do not optimize the expression.

2 points X = ____________________________

Implement gate diagram "A" using all NAND gates. Use the gates as listed under MATERIALS at the beginning of this lab. Draw your NAND gate diagram in the space provided.

10 points

Construct your NAND gate equivalent of gate circuit "A" adding the typical output LED driver to output "X" for a visual indication of the output state.



Place a binary one and zero on the inputs as indicated in the truth table. Record the output condition "X" as a one or zero and place in column "X" in the provided truth table.

16 points

| INPUT | | | | OUTPUT | |
|---|---|---|---|---|---|
| A | B | C | D | X | Z |
| 0 | 0 | 0 | 0 | | |
| 0 | 0 | 0 | 1 | | |
| 0 | 0 | 1 | 0 | | |
| 0 | 0 | 1 | 1 | | |
| 0 | 1 | 0 | 0 | | |
| 0 | 1 | 0 | 1 | | |
| 0 | 1 | 1 | 0 | | |
| 0 | 1 | 1 | 1 | | |
| 1 | 0 | 0 | 0 | | |
| 1 | 0 | 0 | 1 | | |
| 1 | 0 | 1 | 0 | | |
| 1 | 0 | 1 | 1 | | |
| 1 | 1 | 0 | 0 | | |
| 1 | 1 | 0 | 1 | | |
| 1 | 1 | 1 | 0 | | |
| 1 | 1 | 1 | 1 | | |

# ET 115
# Digital
# THE WIRED-OR GATE

Lab #8
16 points

Name(s) ________________________________

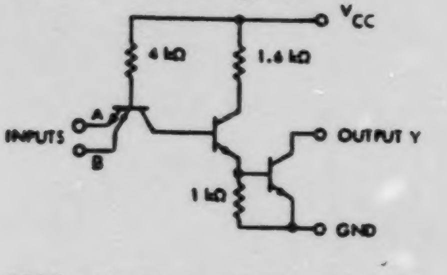
________________________________

**OBJECTIVE:** To observe the operation of a wired-OR gate.

**MATERIALS:** SN7403 TTL open collector NAND gate, 1k ohm, 470 ohm resistor, LED, SN7404.

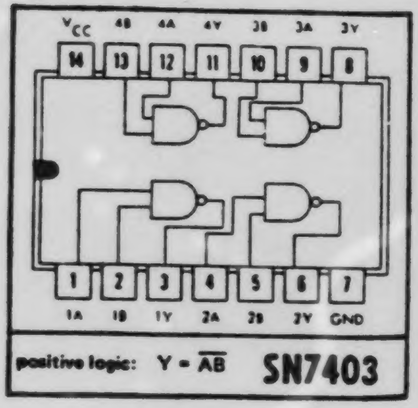
**EQUIPMENT:** Power supply, Proto-board

**PIN-OUT:** schematic (each gate)



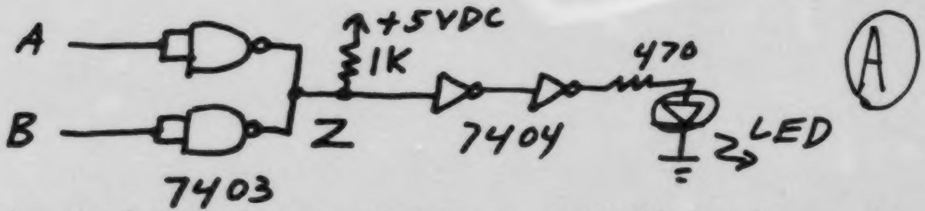
V_CC
4 kΩ
1.6 kΩ
A
INPUTS
B
OUTPUT Y
1 kΩ
GND

NOTE: Component values shown are nominal.



V_CC
4B
4A
4Y
3B
3A
3Y
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1A
1B
1Y
2A
2B
2Y
GND
positive logic: Y = $\overline{AB}$
SN7403

**CIRCUIT:**



A
B
+5VDC
1K
Z
7404
470
LED
7403
A

**PROCEDURE:** Review the information presented in your text "Digital Techniques Book #1" regarding the theory of the wired-or gate. See figure 4-10 and read pages 4-26 and 4-27.

**PROCEDURE:** Construct circuit "A" using the standard LED driver circuit for output state indication. Apply a binary one and zero to the inputs as indicated in the truth table. Record the output "Z" in the proper column.

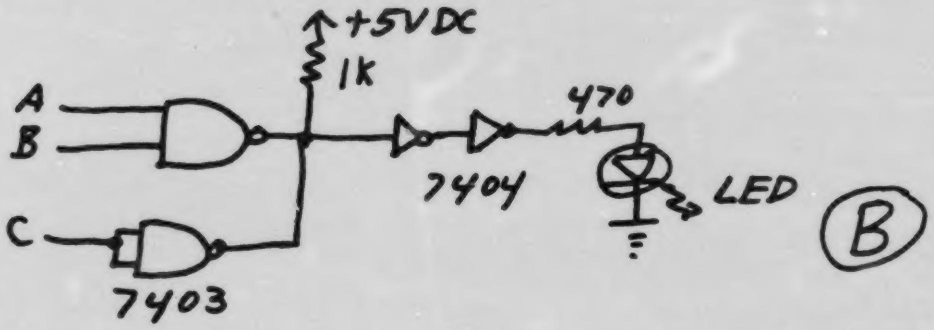
| INPUT | | OUTPUT |
|---|---|---|
| A | B | Z |
| 0 | 0 | |
| 0 | 1 | |
| 1 | 0 | |
| 1 | 1 | |

4 points

The Boolean algebra expression from the truth table is:

2 points Z = ______________________________ Do not reduce the equation.

CIRCUIT:



PROCEDURE: Construct circuit "B". Complete the truth table as indicated.

| INPUT | | | OUTPUT |
|---|---|---|---|
| A | B | C | X |
| 0 | 0 | 0 | |
| 0 | 0 | 1 | |
| 0 | 1 | 0 | |
| 0 | 1 | 1 | |
| 1 | 0 | 0 | |
| 1 | 0 | 1 | |
| 1 | 1 | 0 | |
| 1 | 1 | 1 | |

8 points

The Boolean algebra expression from the truth table is:

2 points X = ______________________________ Do not reduce the equation.

ET 115
Digital
RS FLIP-FLOP

LAB #9
70 points

Name(s)____________________

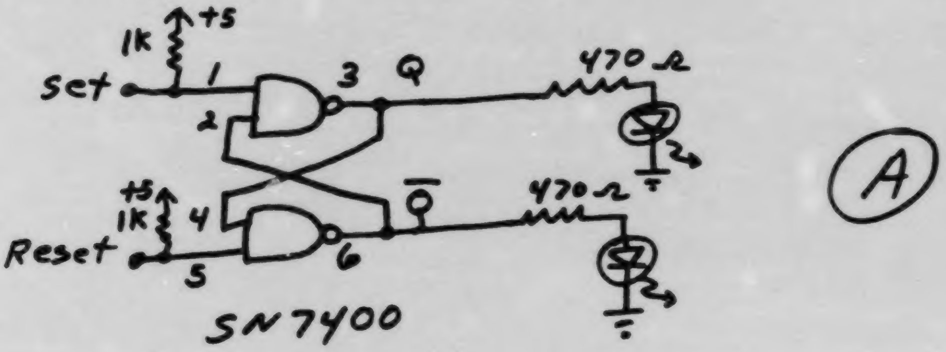
____________________

OBJECTIVE: To observe the characteristics of a RS (latch) flip-flop.

MATERIALS: SN7400, SN 7402, 2-470 ohm and 2-1k ohm resistors, 2-LED's

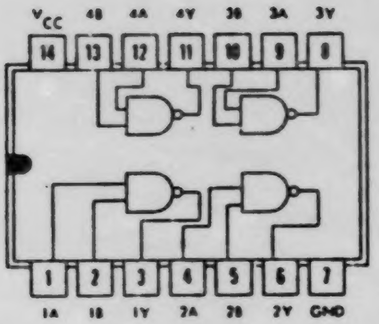
EQUIPMENT: Power supply, proto-board, logic monitor

CIRCUIT:



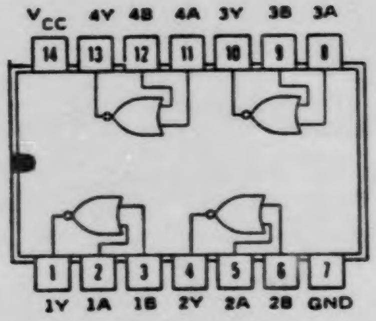
+5
1k
Set
1
2
3
Q
470 Ω
+5
1k
4
$\overline{Q}$
470 Ω
Reset
5
6
SN7400
A

PIN-OUTS:



V_CC
4B
4A
4Y
3B
3A
3Y
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1A
1B
1Y
2A
2B
2Y
GND

**SN7400**



V_CC
4Y
4B
4A
3Y
3B
3A
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1Y
1A
1B
2Y
2A
2B
GND

**SN7402**

PROCEDURE: Construct circuit "A" using the SN7400 NAND gate observing the given IC pin numbers for gate interconnection. Note that pull-up resistors have been added to the set and reset inputs to establish a guaranteed binary one at these inputs.

Apply a binary one and a binary zero to the set and reset inputs as indicated and record in the provided table. Do not remove the pull-up resistors. For a zero on pin number five, connect a jumper from pin five to ground, etc. Remember the inputs are pulled-up to a binary one and will always be a one unless grounded to a binary zero at the gate input.

| SET | RESET | Q | $\overline{Q}$ |
|---|---|---|---|
| 0 | 0 | | |
| 0 | 1 | | |
| 1 | 0 | | |
| 1 | 1 | | |

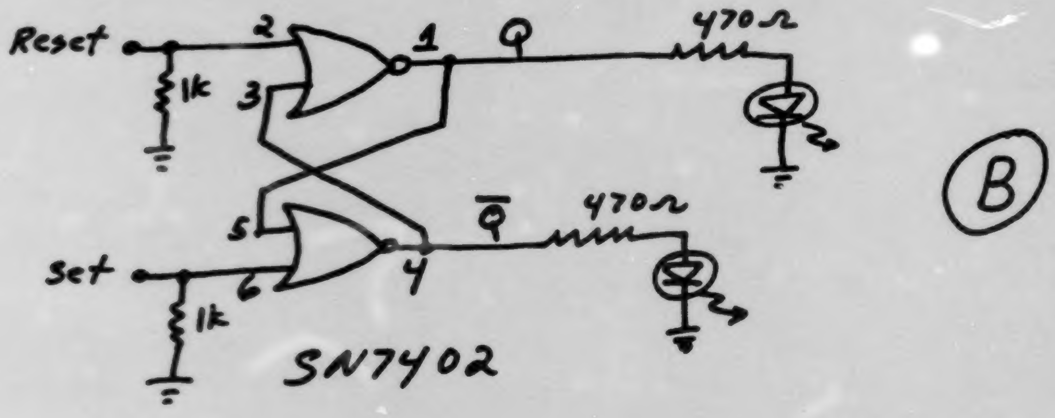
8 points

PROCEDURE: Attach the logic monitor to the chip connecting pin one of the IC to pin one on the monitor. Pin 16 on the monitor will continuously be illuminated indicating pin number 14 on the IC is $V_{CC}$. (The IC is a 14 pin device. This explains the misaligned pin numbers). Using the monitor, indicate the state of all gate inputs and outputs by placing an "X" in the proper column to indicate an illuminated LED (a binary 1).

| Pin Number | SET 1 | RESET 5 | Q 3 | 4 | 2 | $\overline{Q}$ 6 |
|---|---|---|---|---|---|---|
| Set=1 | | | | | | |
| Set=0 | | | | | | |
| Reset=1 | | | | | | |
| Reset=0 | | | | | | |
| Set=Reset=0 | | | | | | |

20 points

CIRCUIT:



PROCEDURE: Construct circuit "B" using the SN7402 NOR gate using the given gate interconnections. Note the pull-down resistors used on the reset and set inputs to guarantee a binary zero at these inputs. Do not remove the pull-down resistors when applying a binary one to the inputs. Complete the truth table as required.

| SET | RESET | Q | $\overline{Q}$ |
|---|---|---|---|
| 0 | 0 | | |
| 0 | 1 | | |
| 1 | 0 | | |
| 1 | 1 | | |

8 points

PROCEDURE: Attach the logic monitor observing the proper pin-outs. Record the requested data placing an "X" in the proper column to indicate a binary one.

| | RESET | SET | Q | | | $\overline{Q}$ |
|---|---|---|---|---|---|---|
| Pin Number | 2 | 6 | 1 | 5 | 3 | 4 |
| Reset=1 | | | | | | |
| Reset=0 | | | | | | |
| Set=1 | | | | | | |
| Set=0 | | | | | | |
| Set=Reset=1 | | | | | | |

20 points

PROCEDURE: Analyze circuits "A" and "B" by comparing the truth tables and answer the following. The basic differences in the two circuits are: (go beyond the fact that they are constructed of an NAND and a NOR gate)

16 points

PROCEDURE: If given either of the circuits be able to describe how they operate in relation to all gate inputs and outputs. This is a thought question and does not require a written response on this lab.

ET 115
Digital
THE "D" FLIP-FLOP

Lab #10
20 points

Name(s) ______________________

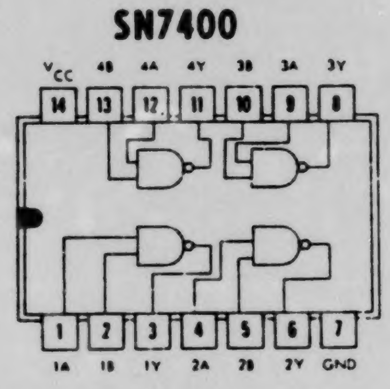
______________________

**OBJECTIVE:** To observe the operation of a "D" type flip-flop constructed from NAND gates.

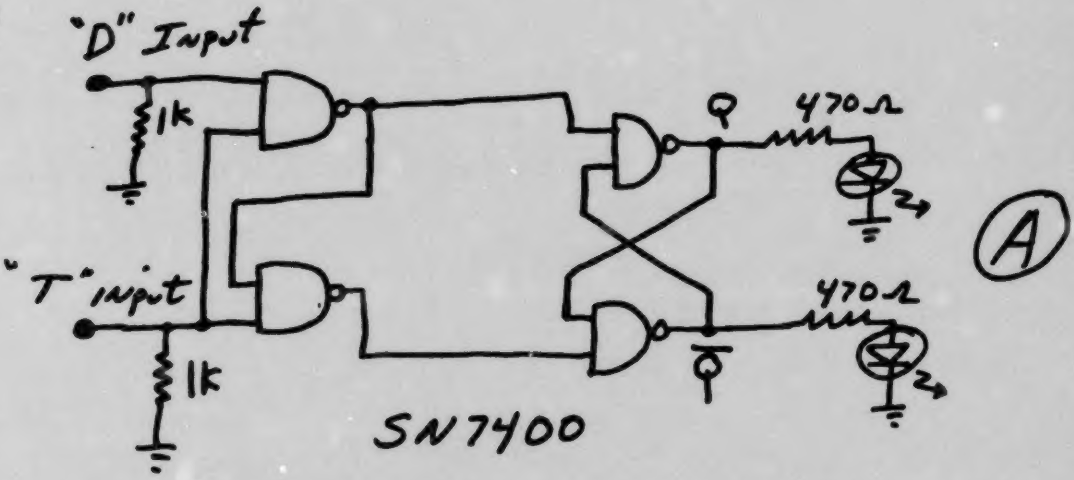
**MATERIALS:** SN7400, 3-470 ohm and 2-1k ohm resistors, 3-LED's

**EQUIPMENT:** Power supply, Proto-board, Function generator

**PIN-OUT**


SN7400
Vcc
4B
4A
4Y
3B
3A
3Y
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1A
1B
1Y
2A
2B
2Y
GND

**CIRCUIT:**


"D" Input
1k
"T" input
1k
Q
$\bar{Q}$
470Ω
470Ω
A
SN7400

**PROCEDURE:** Construct circuit "A". Take note of the pull-down resistors added to the "T" and "D" inputs of the flip-flop. Complete the truth table by applying a binary one and zero as indicated. Place a 1 in the Q-$\bar{Q}$ column to indicate a lit LED.

| Input | | Output | |
|---|---|---|---|
| D | T | Q | $\overline{Q}$ |
| | | | |
| | | | |
| | | | |
| | | | |

8 points

PROCEDURE: Experiment with the circuit to arrive at the answers to the following questions.

1. A binary _________ must be placed on the "T" input and a binary ___________ must be placed on the "D" input to reset the flip-flop.

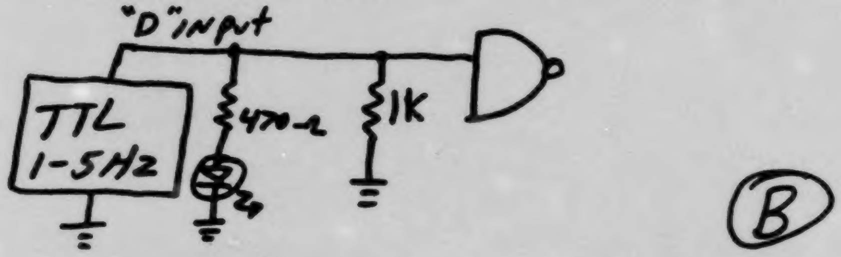
2. To set the flip-flop place a binary _________ on the "D" input and a binary _________ on the "T" input.

3. To in effect latch the flip-flop in a set condition with both inputs at a binary zero, the binary data applied to each of the inputs must be removed in a set order. Remove the data from the "T" and "D" inputs and determine in which sequence the data can be removed and still maintain a flip-flop in the set condition.

   The data must be removed from the _________ input and then removed from the ___________ input to preserve the flip-flop in its set condition.

6 points

CIRCUIT:



PROCEDURE: Add an LED indicator as shown in circuit "B". The remainder of the circuit is unchanged and for that reason will not be redrawn. Apply a 1-5Hz TTL square wave to the "D" input from the function generator. Observe the output LED's to answer the following questions.

1. With the "T" input at a binary zero, describe the state of Q and $\overline{Q}$.

2. With the "T" input at a binary one, describe the state of Q and $\overline{Q}$.

6 points

ET 115
Digital
# THE FOUR BIT STORAGE REGISTER

LAB #11
32 points

Name(s) ____________________

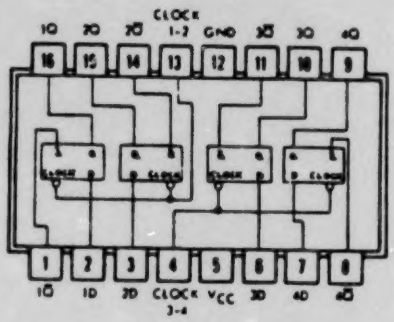
____________________

**OBJECTIVE:** To observe the operation of a four bit bistable latch.

**MATERIALS:** SN7475, 4-470 ohm and 5-1k ohm resistors, 4-LED's

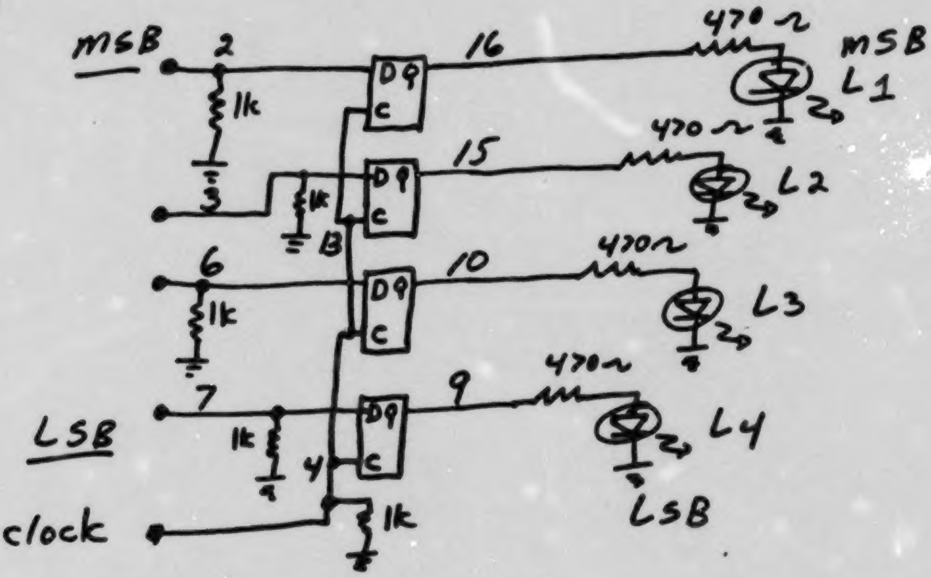
**EQUIPMENT:** Power supply, proto-board

**PIN-OUT:**


1Q
2Q
2Q̄
CLOCK 1-2
GND
3Q̄
3Q
4Q
16
15
14
13
12
11
10
9
1
2
3
4
5
6
7
8
1Q̄
1D
2D
CLOCK 3-4
VCC
3D
4D
4Q̄

SN7475

**CIRCUIT:**


MSB
2
1k
D q
C
16
470 Ω
MSB
L1
15
3
1k
B
470 Ω
L2
6
1k
10
470Ω
L3
7
9
470Ω
LSB
1k
4
L4
LSB
clock
1k

**DESCRIPTION:** The SN7475 contains four "D" type memory elements in a 16 pin DIP package. The device contains a pair of latches that can be clocked (toggled) independently of one another or clocked in pairs. To toggle as a quad latch, connect both the clock (enable) pins together. Place the binary number requiring storage on the "D" input of each latch. To store the data, the clock (enable) is placed at a binary one. At this point the clock (enable) can be brought low (binary zero) and the latch will hold the data regardless of any further "D" input changes. A new binary number may be placed on the "D" inputs and will not be stored until the clock (enable) is again brought high (a binary one).

**PROCEDURE:** Construct the quad latch circuit observing the fact that the IC is a 16 pin device. Also note the unusual location for $V_{CC}$ and ground. Apply a binary one and zero as indicated in the truth table and record the output, state conditions as one for an illuminated LED. (NOTE: In an effort to achieve a consistency of results, it is important to follow the exact sequence as listed in the table. First apply the clock (enable), the input, record the output and then proceed to the next line of the truth table following the same exact sequence.

32 points

| | INPUT | | | | OUTPUT | | | |
|---|---|---|---|---|---|---|---|---|
| CLOCK | D1 | D2 | D3 | D4 | L1 | L2 | L3 | L4 |
| 0 | 1 | 0 | 0 | 1 | | | | |
| 1 | 1 | 0 | 0 | 1 | | | | |
| 0 | 0 | 1 | 1 | 0 | | | | |
| 1 | 0 | 1 | 1 | 0 | | | | |
| 0 | 0 | 0 | 1 | 0 | | | | |
| 0 | 0 | 0 | 1 | 1 | | | | |
| 0 | 0 | 0 | 0 | 0 | | | | |
| 1 | 0 | 0 | 0 | 0 | | | | |

ET 115
Digital
THE JK FLIP-FLOP

Lab #12
65 points

Name(s) ______________________

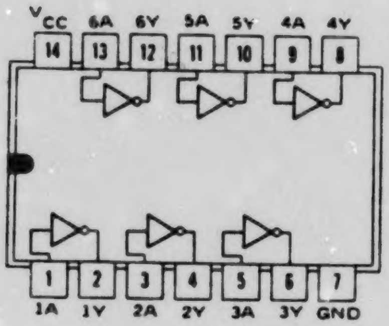
______________________

**OBJECTIVE:** To observe the operational characteristics of a JK FLip-Flop.

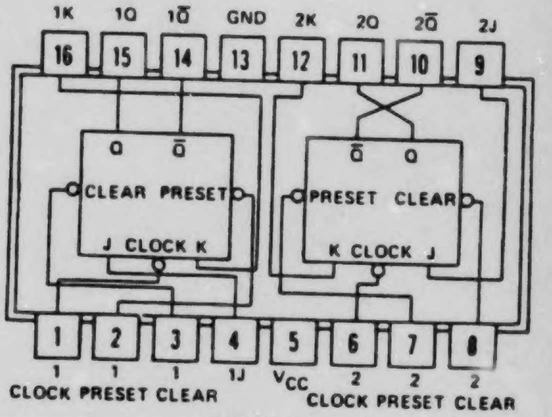
**MATERIALS:** SN7476, SN7404, 4-470 ohm, 6-1k ohm, 1-6.8k ohm, 1-10 ohm, 3-LED's, 1-33uf capacitor.

**EQUIPMENT:** Power supply, Proto-board, Function generator

**PIN-OUTS:**

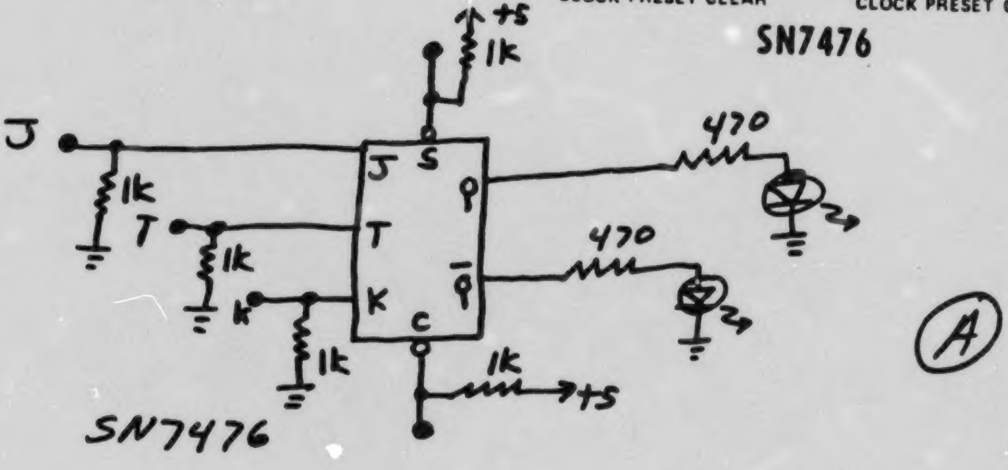

VCC
6A
6Y
5A
5Y
4A
4Y
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1A
1Y
2A
2Y
3A
3Y
GND

**SN7404**


1K
1Q
1Q̄
GND
2K
2Q
2Q̄
2J
16
15
14
13
12
11
10
9
Q
Q̄
CLEAR
PRESET
J CLOCK K
Q̄
Q
PRESET
CLEAR
K CLOCK J
1
2
3
4
5
6
7
8
1 CLOCK
1 PRESET
1 CLEAR
1J
VCC
2 CLOCK
2 PRESET
2 CLEAR

**SN7476**

**CIRCUIT:**


+5
1k
J
1k
T
1k
K
1k
J
S
Q
T
Q̄
K
C
470
470
1k
+5
A
SN7476

**PROCEDURE:** Construct circuit "A" noting the pull-up and pull-down resistors on the various flip-flop inputs. Apply the inputs as indicated in the truth table and record the Q and Q̄ outputs as a binary one or a binary zero.

| INPUTS | | INPUTS | | OUTPUTS | |
|---|---|---|---|---|---|
| J | K | S | C | Q | $\overline{Q}$ |
| 1 | 1 | 1 | 1 | | |
| 1 | 1 | 0 | 1 | | |
| 1 | 1 | 1 | 0 | | |
| 1 | 1 | 0 | 0 | | |
| 0 | 0 | 1 | 1 | | |
| 0 | 0 | 0 | 1 | | |
| 0 | 0 | 1 | 0 | | |
| 0 | 0 | 0 | 0 | | |

16 points

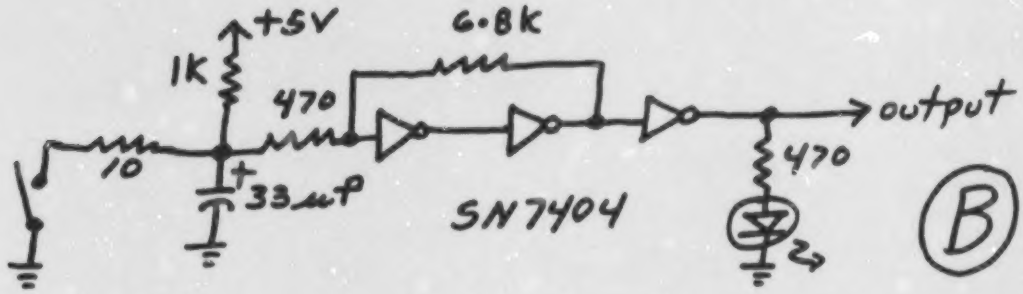
4 points What effect does the JK inputs have on the set and clear inputs in relation to Q and $\overline{Q}$.

PROCEDURE: Input a binary one to both the set and clear inputs. The synchronous operation of the flip-flop is now possible with the application of a binary one to the "T" (clock) input. Input a single pulse to the "T" (clock) input while applying binary ones and zeros as indicated in the truth table. Note: The Q (t + 1) signifies the Q output after the application of a single "T" (clock) input pulse.

| INPUTS | | INPUTS | | OUTPUT | |
|---|---|---|---|---|---|
| J | K | S | C | Q | Q (t + 1) |
| 0 | 0 | 1 | 1 | | |
| 0 | 1 | 1 | 1 | | |
| 1 | 0 | 1 | 1 | | |
| 1 | 1 | 1 | 1 | | |

8 points

CIRCUIT:



**PROCEDURE:** Construct circuit "B". Apply the output of the Schmitt trigger to the "T" (clock) input of the flip-flop. Note: One closure and opening of the switch produces one pulse. Complete the following truth table.

| INPUTS | | INPUTS | | OUTPUT | |
|---|---|---|---|---|---|
| J | K | S | C | Q | Q (t + 1) |
| 0 | 0 | 1 | 1 | | |
| 0 | 1 | 1 | 1 | | |
| 1 | 0 | 1 | 1 | | |
| 1 | 1 | 1 | 1 | | |

8 points

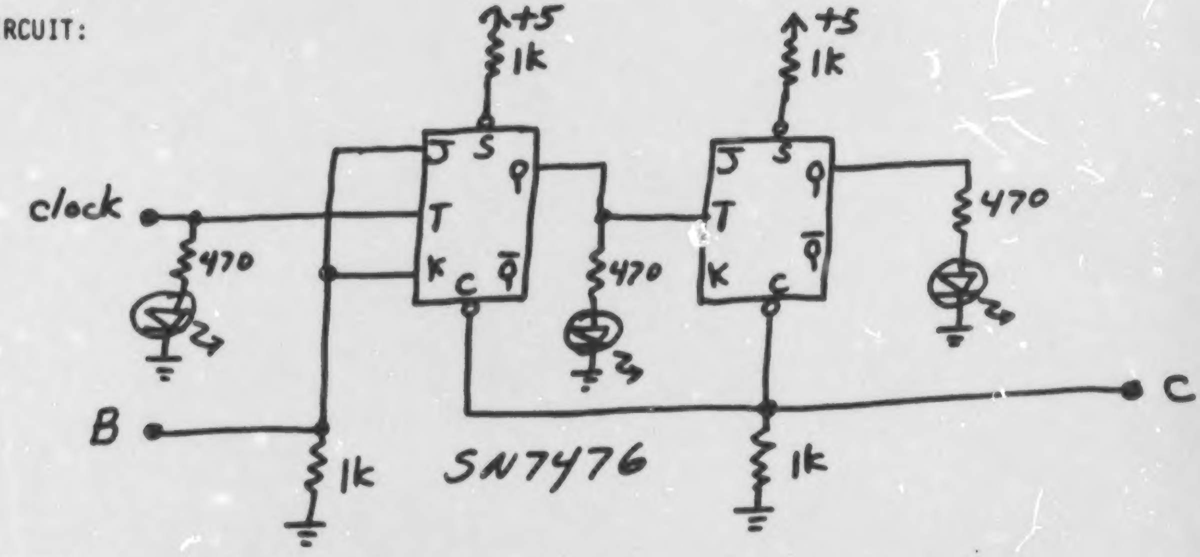
4 points Are the previous two truth tables the same? Yes___ No ___ Why?

4 points Describe any difficulties encountered in regard to depenable clocking of either of the previous circuits.

**PROCEDURE:** Add an LED indicator and resistor to the "T" (clock) input. Apply a 2-8 Hz TTL square wave from the function generator to the "T" (clock) input.

4 points Describe the relationship of the input pulse to the Q and $\overline{Q}$ outputs.

CIRCUIT:



PROCEDURE: Construct circuit "C". Apply a 1-4 Hz TTL signal to the "T" (clock) input of U1. Experiment with the various combinations of inputs B and C and answer the following questions.

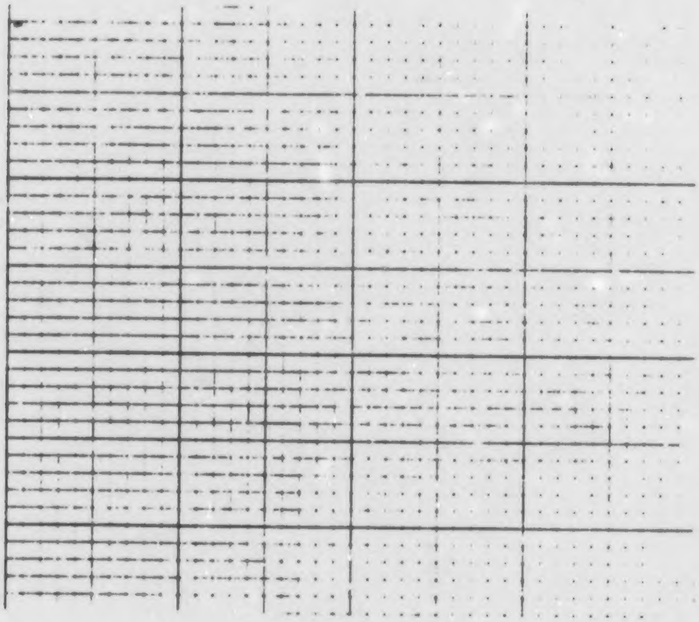
2 points 1. The B input must be a binary _______ and the C input must be a binary _______ for the circuit to provide Q outputs at U1 and U2.

4 points 2. Place a binary 0 on input B. Describe the result. In your response state the purpose of input B, i.e., what does it do.

4 points. 3. Place a binary one on input B. Place a binary zero on input C. Describe the result. In your response state the purpose of input C, i.e., what does it do.

2 points 4. If a frequency of 100 Hz is applied to the clock input (T) of U1 the Q output of U1 is ___________Hz. The Q output of U2 is ______________________Hz.

5 points 5. Draw the timing diagram showing the clock input in relation to Q at U1 and U2. The scope may be used to help define this relationship.



# ET 115
# Digital
# THE BINARY COUNTER

Lab #13
56 points

Name(s) ______________________________

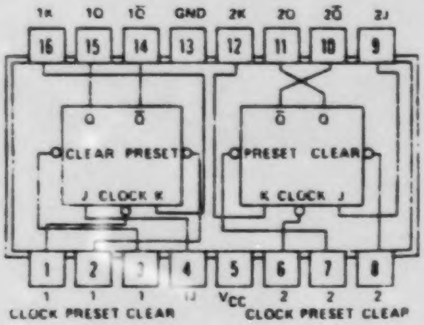
______________________________

**OBJECTIVE:** To observe the operation of a binary counter constructed using flip-flops.

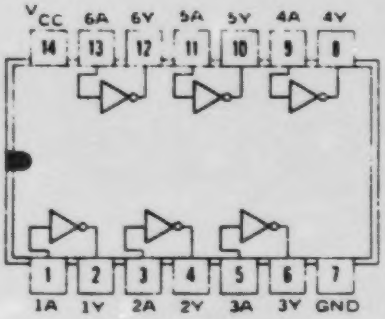
**MATERIALS:** 2-SN7476, SN7404, 6-470 ohm, 3-1k ohm, 1-6.8k ohm, 1-10 ohm, 5-LED's, 1-33uf capacitor

**EQUIPMENT:** Power supply, Proto-board, Function generator

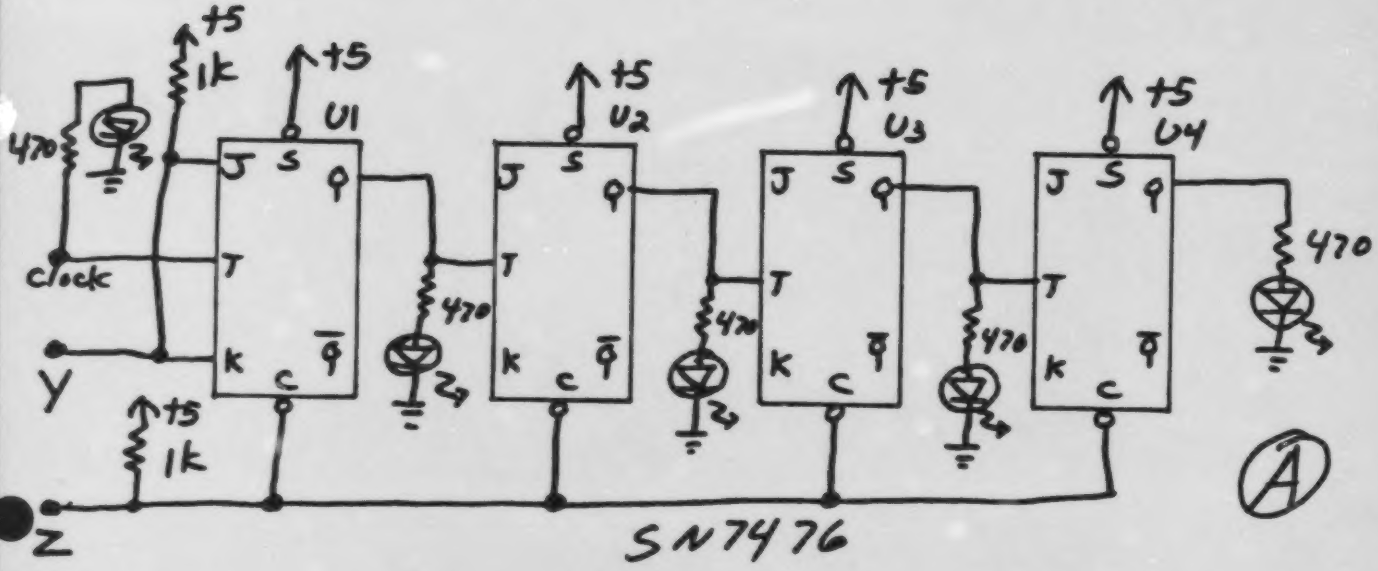
**PIN-OUTS:**


1K 1Q 1Q̄ GND 2K 2Q 2Q̄ 2J
16 15 14 13 12 11 10 9
Q Q̄ CLEAR PRESET J CLOCK K
Q̄ Q PRESET CLEAR K CLOCK J
1 2 3 4 5 6 7 8
1 CLOCK 1 PRESET 1 CLEAR 1J VCC 2 CLOCK 2 PRESET 2 CLEAR

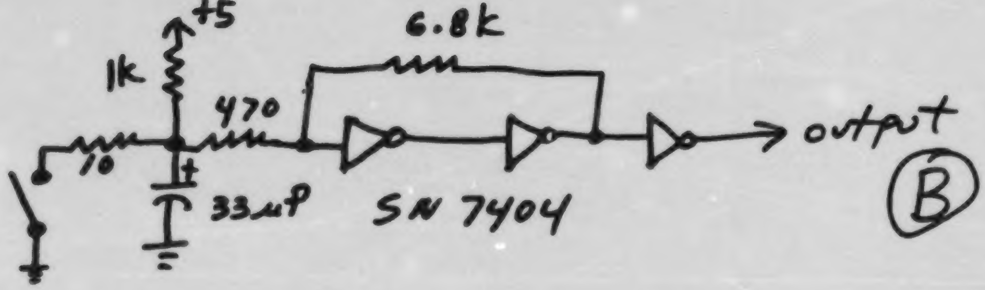
SN7476


VCC 6A 6Y 5A 5Y 4A 4Y
14 13 12 11 10 9 8
1 2 3 4 5 6 7
1A 1Y 2A 2Y 3A 3Y GND

SN7404


+5
1k
470
Clock
Y
+5
1k
Z
+5
U1
J S Q
T
K C Q̄
470
+5
U2
J S Q
T
K C Q̄
470
+5
U3
J S Q
T
K C Q̄
470
+5
U4
J S Q
T
K C Q̄
470
A
SN7476

CIRCUIT:



PROCEDURE: Construct circuit "A" on four bit binary counter and circuit "B" a Schmitt trigger. Apply a 2-4 Hz TTL square wave to the clock ("T") input on U1 using the function generator. Alter the states of inputs Y and Z by placing a variety of combinations of ones and zeros on these inputs. Answer the following questions in regard to the effects inputs Y and Z have on circuit operation.

4 points 1. Describe the result when a binary zero is placed on input Y.

4 points 2. Describe the result when a binary zero is placed on input Z.

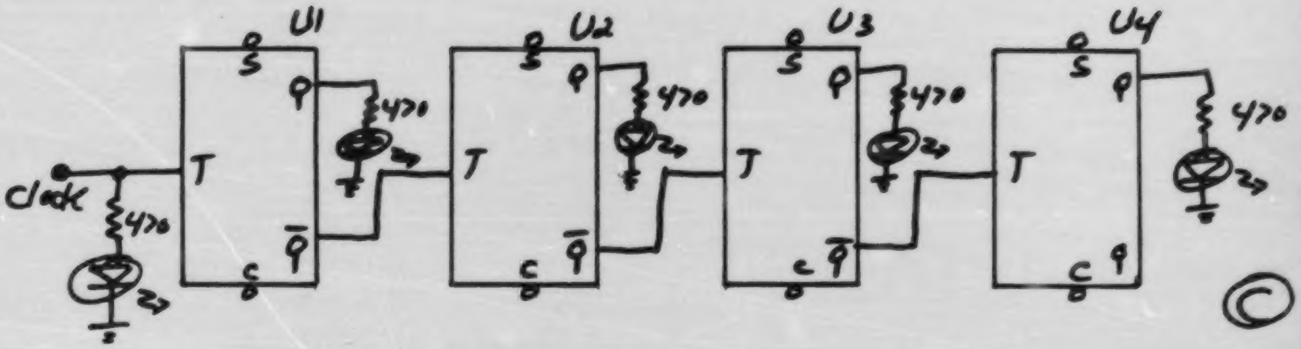
4 points 3. What purpose does placing a binary zero on input Z serve.

PROCEDURE: Disconnect the function generator from the circuit and connect the Schmitt trigger in its place. Slowly pulse the circuit until all the LED's are indicating a binary zero output from U1 through U4. Complete the truth table by observing the state of each flip-flop and recording the data as ones and zeros.

17 points

|  | MSB<br>U4 | U3 | U2 | LSB<br>U1 |  | MSB<br>U4 | U3 | U2 | LSB<br>U1 |
|---|---|---|---|---|---|---|---|---|---|
| 0 |  |  |  |  | 8 |  |  |  |  |
| 1 |  |  |  |  | 9 |  |  |  |  |
| 2 |  |  |  |  | 10 |  |  |  |  |
| 3 |  |  |  |  | 11 |  |  |  |  |
| 4 |  |  |  |  | 12 |  |  |  |  |
| 5 |  |  |  |  | 13 |  |  |  |  |
| 6 |  |  |  |  | 14 |  |  |  |  |
| 7 |  |  |  |  | 15 |  |  |  |  |
| 8 |  |  |  |  | 16 |  |  |  |  |

CIRCUIT:



**NOTE:** This is a simplified diagram indicating circuit alterations only on the "T" and Q inputs and outputs

PROCEDURE: Construct circuit "C". The only difference in the diagram is that clock ("T") inputs are connected to the Q output instead of Q output. Apply a 2-4 Hz TTL square wave to the clock input on U1. Answer the following questions.

4 points. 1. Place a binary zero on input Y and describe the result.

1 point 2. Compare circuit "A" with "B". Are the effects of a binary zero on input Y the same or different for the two circuits.

4 points 3. Place a binary zero on input Z and describe the result.

1 point 4. Compare circuit "A" with "B". Are the effects of a binary zero on input Z the same or different for the two circuits.

PROCEDURE: Disconnect the function generator from the circuit and connect the Schmitt trigger in its place. Slowly pulse the circuit until LED's U1 through U4 are at binary zeros. Complete the truth table by observing the output state of each flip-flop and recording the data as ones and zeros. Also convert the displayed binary number into its decimal equivalent and record as each pulse sequences the counter.

| Number of clock pulses | MSB U4 | U3 | U2 | LSB U1 | Decimal Number |
|---|---|---|---|---|---|
| 0 | | | | | |
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |
| 11 | | | | | |
| 12 | | | | | |
| 13 | | | | | |
| 14 | | | | | |
| 15 | | | | | |
| 16 | | | | | |

17 points

ET 115
Digital
SYNCHRONOUS BINARY COUNTER

Lab #14
95 points

Name(s) ____________________

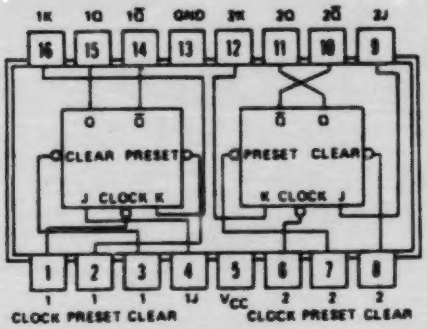
____________________

**OBJECTIVE:** To observe the operation of a TTL MSI synchronous up/down counter.

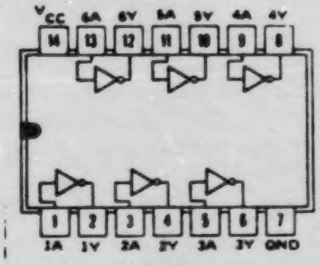
**MATERIALS:** SN74193, SN7476, SN7404, 7-470 ohm, 5-1k ohm, 1-6.8k ohm, 1-10 ohm, 1-33uf capacitor, 6-LED's.

**EQUIPMENT:** Power supply, Proto-board, Function generator, Oscilloscope

**PIN-OUTS:**


1K
1Q
1Q̄
GND
2K
2Q
2Q̄
2J
16
15
14
13
12
11
10
9
Q
Q̄
CLEAR PRESET
J CLOCK K
Q̄
Q
PRESET CLEAR
K CLOCK J
1
2
3
4
5
6
7
8
1 CLOCK
1 PRESET
1 CLEAR
1J
VCC
2 CLOCK
2 PRESET
2 CLEAR

**SN7476**


VCC
6A
6Y
5A
5Y
4A
4Y
14
13
12
11
10
9
8
1
2
3
4
5
6
7
1A
1Y
2A
2Y
3A
3Y
GND

**SN7404**

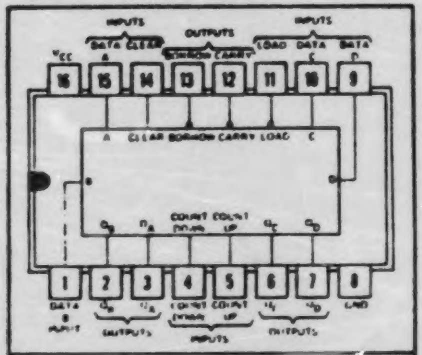
DATA:

## TTL MSI CIRCUIT TYPES SN54192, SN54193, SN74192, SN74193
## SYNCHRONOUS 4-BIT UP/DOWN COUNTERS DUAL CLOCK WITH CLEAR

- Cascading Circuitry Provided Internally
- Synchronous Operation
- Individual Preset to Each Flip-Flop
- Fully Independent Clear Input
- Typical Maximum Input Count Frequency . . . 32 MHz

These monolithic circuits are synchronous reversible (up/down) counters having a complexity of 55 equivalent gates. The SN54192 and SN74192 are BCD counters and the SN54193 and SN74193 are 4-bit binary counters. Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincidently with each other when so instructed by the steering logic. This mode of operation eliminates the output counting spikes which are normally associated with asynchronous (ripple-clock) counters.

J OR N
DUAL-IN-LINE PACKAGE (TOP VIEW)


INPUTS
DATA A
CLEAR
OUTPUTS
BORROW
CARRY
INPUTS
LOAD
DATA C
DATA D
VCC
16
15
14
13
12
11
10
9
A
CLEAR
BORROW
CARRY
LOAD
C
B
D
QB
QA
COUNT DOWN
COUNT UP
QC
QD
1
2
3
4
5
6
7
8
DATA B INPUT
QB
QA
OUTPUTS
COUNT DOWN
COUNT UP
INPUTS
QC
QD
OUTPUTS
GND

**logic:** Low input to load sets $Q_A = A$, $Q_B = B$, $Q_C = C$, and $Q_D = D$

The outputs of the four master-slave flip-flops are triggered by a low-to-high-level transition of either count (clock) input. The direction of counting is determined by which count input is pulsed while the other count input is high.

CIRCUIT TYPES SN54192, SN54193, SN74192, SN74193
BULLETIN NO. DL-S 7011311, FEBRUARY 1970

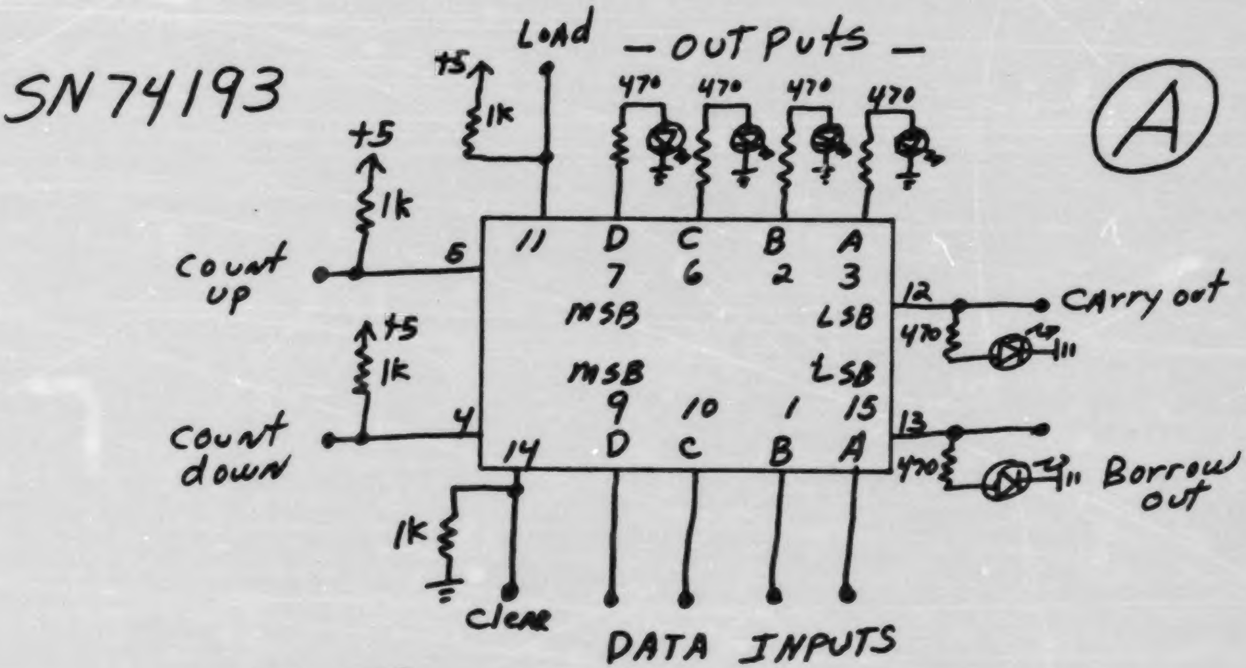
All four counters are fully programmable; that is, the outputs may be preset to any state by entering the desired data at the data inputs while the load input is low. The output will change to agree with the data inputs independently of the count pulses. This feature allows the counters to be used as modulo-N dividers by simply modifying the count length with the preset inputs.

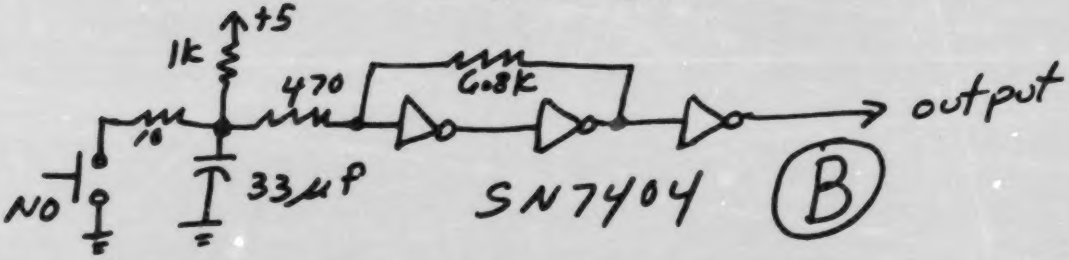
A clear input has been provided which forces all outputs to the low level when a high level is applied. The clear function is independent of the count and load inputs. An input buffer has been placed on the clear, count, and load inputs to lower the drive requirements to one normalized Series 54/74 load. This is important when the output of the driving circuitry is somewhat limited.

These counters were designed to be cascaded without the need for external circuitry. Both borrow and carry outputs are available to cascade both the up- and down-counting functions. The borrow output produces a pulse equal in width to the count-down input when the counter underflows. Similarly, the carry output produces a pulse equal in width to the count-up input when an overflow condition exists. The counters can then be easily cascaded by feeding the borrow and carry outputs to the count-down and count-up inputs respectively of the succeeding counter.

Power dissipation is typically 325 milliwatts for either the decade or binary version. Maximum input count frequency is typically 32 megahertz and is guaranteed to be 25 MHz minimum. All inputs are buffered and represent only one normalized Series 54/74 load. Input clamping diodes are provided to minimize transmission-line effects and thereby simplify system design. The SN54192 and SN54193 are characterized for operation over the full military temperature range of −55°C to 125°C; the SN74192 and SN74193 are characterized for operation from 0°C to 70°C.

CIRCUITS:





PROCEDURE: Read the TI data sheet to become familiar with the operation of the SN74193. Construct circuits "A" and "B". Reset the counter, outputs A through D to all zeros using the clear input. Connect the output of the Schmitt trigger to the count up input. If the output changes from all zeros to some random number when the Schmit trigger is connected it will be necessary to again clear the counter. Pulse the counter slowly and observe the outputs A through D, borrow and carry. Record the data in the truth table.

17 points

| Count Up | OUTPUTS D | C | B | A | Carry | Borrow |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |
| 13 | | | | | | |
| 14 | | | | | | |
| 15 | | | | | | |
| 16 | | | | | | |

PROCEDURE: Disconnect the Schmitt trigger from the count up input and reconnect to the count down input. Clear the counter, pulse, observe the outputs and record the requested data in the truth table.

17 points

| Count Up | OUTPUTS | | | | Carry | Borrow |
|---|---|---|---|---|---|---|
| | D | C | B | A | | |
| 0 | | | | | | |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| 8 | | | | | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| 12 | | | | | | |
| 13 | | | | | | |
| 14 | | | | | | |
| 15 | | | | | | |
| 16 | | | | | | |
| | | | | | | |

PROCEDURE: Answer the following questions using the two previous truth tables.

2 points 1. To reset the counter a binary __________ must be placed on the __________ input.

2 points 2. When counting up the decimal number ________, as converted from the binary output, must be present to obtain a binary ________ in the carry column.

1 point 3. When counting down the binary output after one pulse is entered is a binary ________.

1 point 4. When counting down it takes ________ input pulses to produce a zero in the borrow column.

PROCEDURE: Using the data inputs A through D, input a decimal 9 by placing a binary one on the D and A inputs and a binary one on the B and C inputs. Load the data by bringing the load input to a binary zero. Connect the Schmitt trigger to the up count input. Clear the counter, load the counter, pulse and answer the following.

1 point 1. After the counter has been loaded with a decimal 9 it takes ________ pulses to achieve a binary zero output. (ouputs A through D)

1 point 2. Load in a decimal 9. It now takes ________ pulses to achieve a zero on the carry output.

1 point 3. Load in a decimal 12. It now takes ________ pulses to achieve a zero on the carry output.

1 point 4. To operate the counter as a divide by 5 counter it is necessary to load a decimal ________ into the counter.

PROCEDURE: Preset the inputs A through D for a decimal 11. Connect the load input to the carry output. With the Schmitt trigger connected to the up count input, clear the counter, input 28 pulses and complete the truth table. Record data starting at pulse number 14.

| Count up Pulses | D | C | B | A |
|---|---|---|---|---|
| 14 | | | | |
| 15 | | | | |
| 16 | | | | |
| 17 | | | | |
| 18 | | | | |
| 19 | | | | |
| 20 | | | | |
| 21 | | | | |

Continued on next page

| | | | | |
|---|---|---|---|---|
| 22 | | | | |
| 23 | | | | |
| 24 | | | | |
| 25 | | | | |
| 26 | | | | |
| 27 | | | | |
| 28 | | | | |

15 points

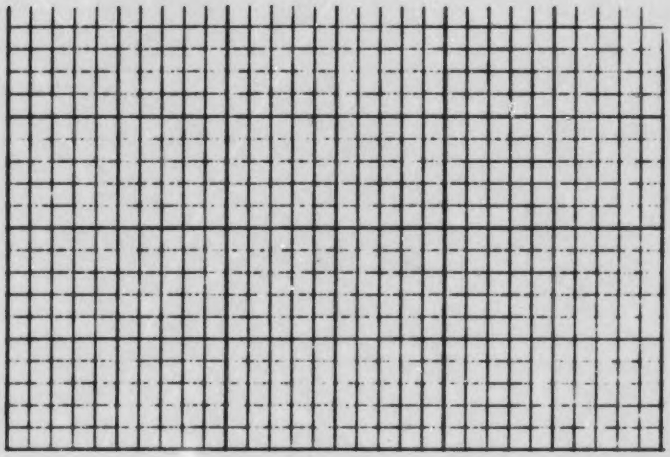
PROCEDURE: Answer the following. Use the data from the above truth table.

1 point 1. The counter resets on pulse numbers ____________________.

1 point 2. The counter repeats its pulse sequence every ______ pulses.

1 point 3. In this configuration the counter is said to be a divide by ____________ counter.

PROCEDURE: Connect the scope to the count up input and the carry output using both probs. Disconnect the Schmitt trigger and input a 1 KHz TTL square wave from the function generator to the count up input. Observe and record both the input and output pulses.



8 points

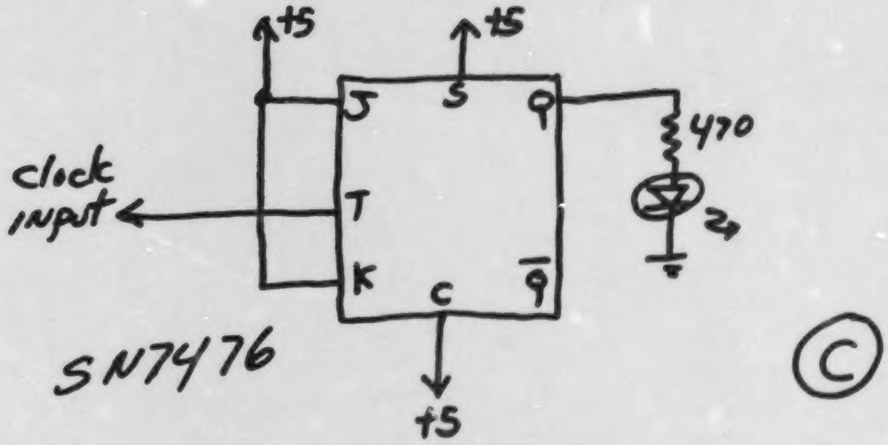
PROCEDURE: Answer the following questions.

2 points 1. The carry pulse is ____________________ going and occurs
negative-positive
once for every ____________ input pulses.

2 points 2. The carry pulse has a pulse width of ___________ seconds and a pulse height of _____________ volts.

5 points 3. If you are unable to answer the above two questions, state your reasons why. If you answered the above questions and if you encountered any difficulties in obtaining the data, state what difficulties were encountered.

CIRCUIT:



PROCEDURE: Construct circuit "C". Add the JK flip-flop to the counter by connecting the "T" or clock input to the carry output of the binary counter. Remove the LED and resistor from the carry output and place the LED and resistor on the Q flip-flop output. Using the function generator, input to the count up input a 2-8 Hz TTL square wave. The Q output from the flip-flop will indicate the presence of the carry output pulse.

**PROCEDURE:** Connect the scope to the count up input and to the flip-flop Q output. Increase the applied frequency to 1 KHz and record the resultant waveforms when the preset inputs are set at a decimal 11 (a binary 1 0 1 1).

8 points

**PROCEDURE:** Alter the preset input to a decimal 8 and record the waveforms.

8 points

# ET 115
# Digital
# BCD COUNTER

Lab #15
55 points

Name(s) ____________________

____________________

OBJECTIVE: To observe the operation of a BCD decade counter

MATERIALS: SN7490, 2-1k ohm, 4-470 ohm, 4-LED's

EQUIPMENT: Power supply, Proto-board, Function generator

DATA SHEET:

## DECADE COUNTER

## N7490

S5490—A,F,W • N7490—A,F

**DIGITAL 54/74 TTL SERIES**

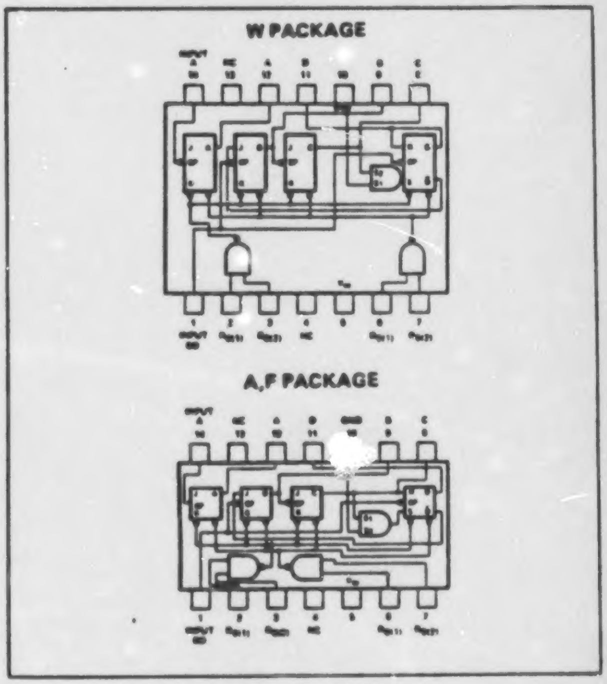
### DESCRIPTION

The S5490/N7490 is a high-speed, monolithic decade counter consisting of four dual-rank, master-slave flip-flops internally interconnected to provide a divide-by-two counter and a divide-by-five counter. Gated direct reset lines are provided to inhibit count inputs and return all outputs to a logical "0" or to a binary coded decimal (BCD) count of 9. As the output from flip-flop A is not internally connected to the succeeding stages, the count may be separated in three independent count modes:

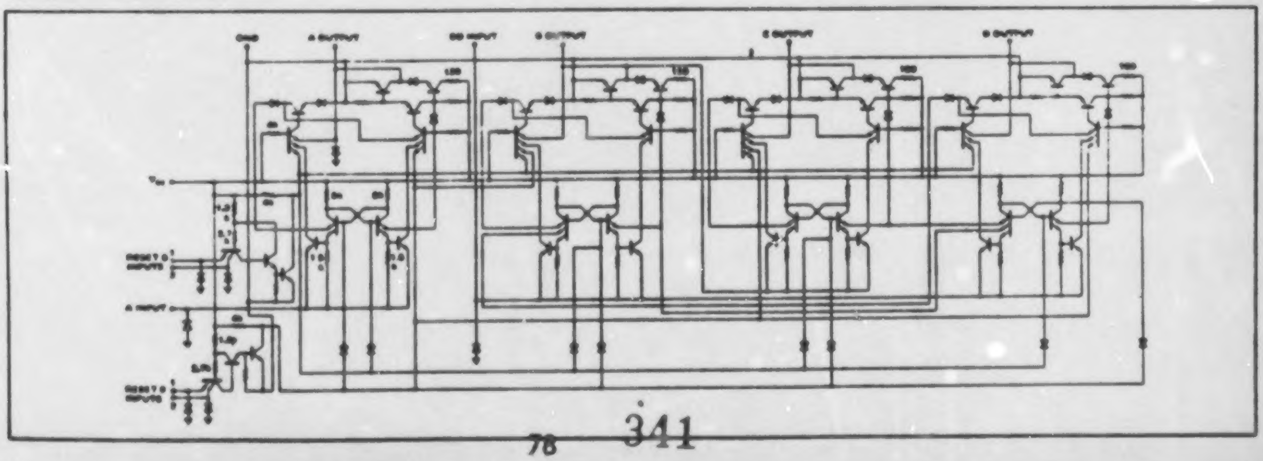
1. When used as a binary coded decimal decade counter, the BD input must be externally connected to the A output. The A input receives the incoming count, and a count sequence is obtained in accordance with the BCD count sequence truth table shown above. In addition to a conventional "0" reset, inputs are provided to reset a BCD 9 count for nine's complement decimal applications.
2. If a symmetrical divide-by-ten count is desired for frequency synthesizers or other applications requiring division of a binary count by a power of ten, the D output must be externally connected to the A input. The input count is then applied at the BD input and a divide-by-ten square wave is obtained at output A.
3. For operation as a divide-by-two counter and divide-by-five counter, no external interconnections are required. Flip-flop A is used as a binary element for the divide-by-two function. The BD input is used to obtain binary divide-by-five operation at the B, C, and D outputs. In this mode, the two counters operate independently; however, all four flip-flops are reset simultaneously.

The 5490/7490 is completely compatible with Series 54 and Series 74 logic familes. Average power dissipation is 160mW.

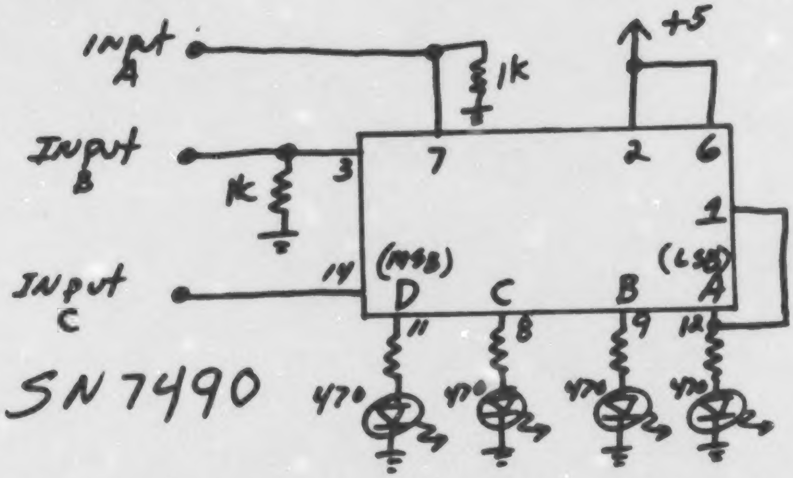
### PIN CONFIGURATIONS



### SCHEMATIC DIAGRAM



CIRCUIT:


input A
1k
+5
Input B
1k
3
7
2
6
1
Input C
14
(MSB)
(LSB)
D
C
B
A
11
8
9
12
SN7490
470
470
470
470

PROCEDURE: Read the information contained in the data sheet before constructing the circuit. Once the data is read and understood, construct the BCD counter.

Input a 1-4 Hz TTL square wave from the function generator into input C. Place a binary one on input A, then on input B and observe the counter LED output. Using this observation answer the following questions.

5 points 1. What is the result when input A is brought high.

5 points 2. What is the purpose of input A.

5 points 3. What is the result when input B is brought high.

5 points 4. What is the purpose of input B.

PROCEDURE: Using the function generator or a Schmitt trigger, complete the truth table starting with a BCD 0000.

| | OUTPUT | | | |
|---|---|---|---|---|
| COUNT | D | C | B | A |
| 0 | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |

11 points

PROCEDURE: Answer the following questions.

1 point 1. The counter resets on every _________ pulse.

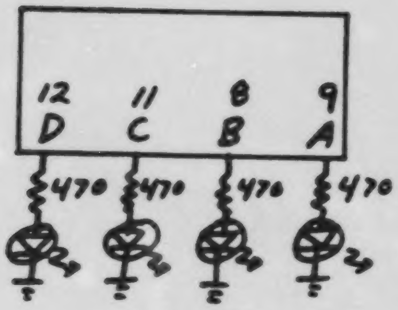
1 point 2. This counter is a divide by __________ counter.

2 points 3. The IC circuit consists of one divide by ________ counter and one divide by ____________ counter.

PROCEDURE: Using the information presented in the data sheet, rewire the counter into a symmetrical divide by ten counter and record the input and output waveforms.

10 points

CIRCUIT:


12
11
8
9
D
C
B
A
470
470
470
470

PROCEDURE: Rewire the LED indicators as shown and complete the truth table for the symmetrical counter.

| COUNT | OUTPUT D | C | B | A |
|---|---|---|---|---|
| 0 | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |

10 points

ET 115
Digital
4 BIT SHIFT REGISTER

Lab #16
79 points

Name(s) ______________________

______________________

OBJECTIVE: To use the supplied data in the engineering of circuits to demonstrate the three unique modes of operation of a 4 bit right-shift, lef-shift, shift register.

MATERIALS: SN7495, 4-470 ohm, 4-LED's and other resistors as deemed necessary by the design staff.

EQUIPMENT: Power supply, Proto-board, Function generator

DATA SHEET: **signetics**

## 4-BIT RIGHT-SHIFT LEFT-SHIFT REGISTER

## N7495

S5495—A,F • N7495—A,F

DIGITAL 54/74 TTL SERIES

### DESCRIPTION

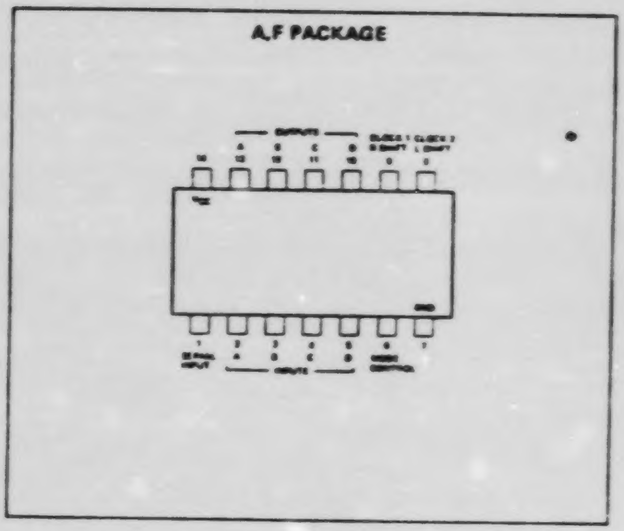
The 54/7495 is a monolithic universal 4-Bit Shift Register designed with standard TTL techniques. The circuit layout consists of 4 R-S master-slave flip-flops, 4 AND-OR-INVERT gates, and 6 inverters configured to form a versatile register which will perform right-shift, left-shift, or parallel-in, parallel-out operations depending on the logical input level to the mode control.

Right-shift operations are performed when a logical 0 level is applied to the mode control. Serial data is entered at the serial input $D_S$ and shifted one position right on each clock 1 pulse. In this mode, clock 2 and parallel inputs $D_A$ thru $D_D$ are inhibited.

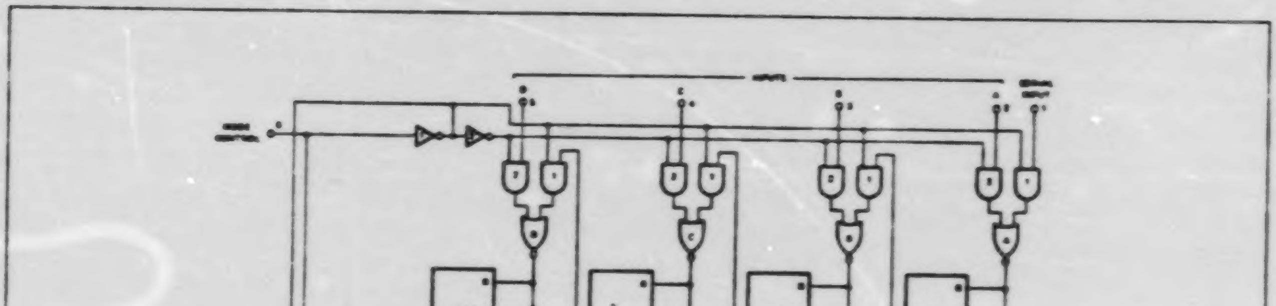
Parallel-in, parallel-out operations are performed when a logical 1 level is applied to the mode control. Parallel data is entered at parallel inputs $D_A$ thru $D_D$ and is transferred to the data outputs $A_0$ thru $D_0$ on each clock 2 pulse. In this mode, shift-left operations may be implemented by externally tying the output of each flip-flop to the parallel input of the previous flip-flop ($D_0$ to $D_C$ and etc.), with serial data entry at input $D_D$.

Information must be present at the R-S inputs prior to clocking and transfer of data occurs on the falling edge of the clock pulse.

### PIN CONFIGURATIONS



### LOGIC DIAGRAM



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**description**

This monolithic shift register, utilizing transistor-transistor-logic (TTL) circuits in the familiar Series 54/74 configuration, is composed of four R-S master-slave flip-flops, four AND-OR-INVERT gates, one AND-OR gate, and six inverters-drivers. Internal interconnections of these functions provide a versatile register which will perform right-shift or left-shift operations dependent upon the logical input level to the mode control. A number of these registers may be connected in series to form an n-bit right-shift or left-shift register. This register can also be used as a parallel-in, parallel-out storage register with gate (mode) control.

When a logical 0 level is applied to the mode control input, the number-1 AND gates are enabled and the number-2 AND gates are inhibited. In this mode the output of each flip-flop is coupled to the R-S inputs of the succeeding flip-flop and right-shift operation is performed by clocking at the clock 1 input. In this mode, serial data is entered at the serial input. Clock 2 and parallel inputs A through D are inhibited by the number-2 AND gates.

When a logical 1 level is applied to the mode control input, the number-1 AND gates are inhibited (decoupling the outputs from the succeeding R-S inputs to prevent right-shift) and the number-2 AND gates are enabled to allow entry of data through parallel inputs A through D and clock 2. This mode permits parallel loading of the register, or with external interconnection, shift-left operation. In this mode, shift-left can be accomplished by connecting the output of each flip-flop to the parallel input of the previous flip-flop ($Q_D$ to input C, and etc.), and serial data is entered at input D.

Clocking for the shift register is accomplished through the AND-OR gate E which permits separate clock sources to be used for the shift-right and shift-left modes. If both modes can be clocked from the same source, the clock input may be applied commonly to clock 1 and clock 2. Information must be present at the R-S inputs of the master-slave flip-flops prior to clocking. Transfer of information to the output pins occurs when the clock input goes from a logical 1 to a logical 0.

This shift register is completely compatible with Series 54/74 TTL and DTL logic families. Average power dissipation is typically 195 milliwatts. The SN5495A and SN7495A are unilaterally interchangeable with and replace SN5495 and SN7495, respectively, but offer diode-clamped inputs, improved speed, and reduced power dissipation.

PROCEDURE: Carefully read the data sheet, taking the time to gain an understanding of the circuits function and operation for each of its three modes of operation.

Following the data as presented, design a circuit using only the SN7495 that will perform a serial right-shift operation. Use the function generator to clock the circuit through its sequence. Indicate the state of each input-output by placing a one, a zero, clock or a NA (not applicable) in the provided blanks. After a description of the LED output sequence is recorded, draw the actual circuit interconnections used to arrive at your functional circuit.

Pin 1 ______________

Pin 2 ______________

Pin 3 ______________

8 points Pin 4 ______________

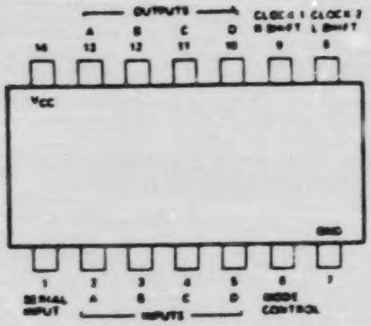
Pin 5 ______________

Pin 6 ______________

Pin 8 ______________

Pin 9 ______________

**CIRCUIT:** Serial Right-Shift Operation
5 points


OUTPUTS
A
B
C
D
CLOCK 1 R SHIFT
CLOCK 2 L SHIFT
14
13
12
11
10
9
8
VCC
GND
1
2
3
4
5
6
7
SERIAL INPUT
A
B
C
D
INPUTS
MODE CONTROL

5 points Describe the input conditions necessary to achieve an operational circuit, i.e., what inputs must be binary ones, zeros and clocked in order for the circuit to function.

5 points Record your observations using the LED's as a guide. Describe the LED sequence under your various test conditions.

**PROCEDURE:** Design a circuit for parallel-in, parallel-out operations following the same guidelines as stipulated in the prior design.

Pin 1 ______________ Pin 5 ______________

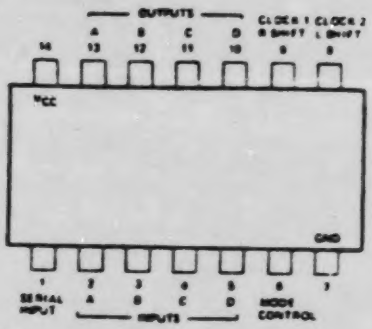
Pin 2 ______________ Pin 6 ______________

Pin 3 ______________ Pin 8 ______________

8 points Pin 4 ______________ Pin 9 ______________

**CIRCUIT:** Parallel-In, Parallel-Out Operation

5 points


OUTPUTS
A
B
C
D
CLOCK 1 R SHIFT
CLOCK 2 L SHIFT
14
13
12
11
10
9
8
VCC
GND
1
2
3
4
5
6
7
SERIAL INPUT
A
B
C
D
INPUTS
MODE CONTROL

5 points Describe the input conditions necessary to achieve an operational circuit, i.e., what inputs must be binary ones, zeros and clocked in order for the circuit to function.

5 points Record your observations using the LED's as a guide. Describe the LED sequence under your various test conditions.

**PROCEDURE:** Design a circuit for serial shift-left operations. It will be necessary to remove binary ones and zeros from inputs A through D. Note that the serial input for left-shift occurs at input D.

Pin 1 ______________

Pin 2 ______________

Pin 3 ______________

8 points Pin 4 ______________

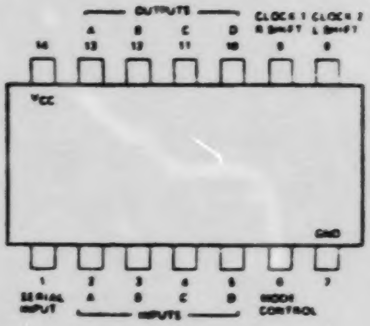
Pin 5 ______________

Pin 6 ______________

Pin 8 ______________

Pin 9 ______________

CIRCUIT: Serial Shift-Left Operation
5 points


OUTPUTS
A
B
C
D
CLOCK 1 R SHIFT
CLOCK 2 L SHIFT
14
13
12
11
10
9
8
VCC
GND
1
2
3
4
5
6
7
SERIAL INPUT
A
B
C
D
INPUTS
MODE CONTROL

5 points Describe the input conditions necessary to achieve an operational circuit, i.e., what inputs must be binary ones, zeros and clocked in order for the circuit to function.

5 points Record your observations using the LED's as a guide. Describe the LED sequence under your various test conditions.

10 points Placing a binary one on the serial left shift input (pin #5), describe in simple terms, using the gates as numbered in the logic diagram, how the left-shift sequence occurs for each clock input, i.e., how does the circuit work.

ET 115
Digital
THE CLOCK OSCILLATOR

Lab #17
65 points

Name(s) ____________________

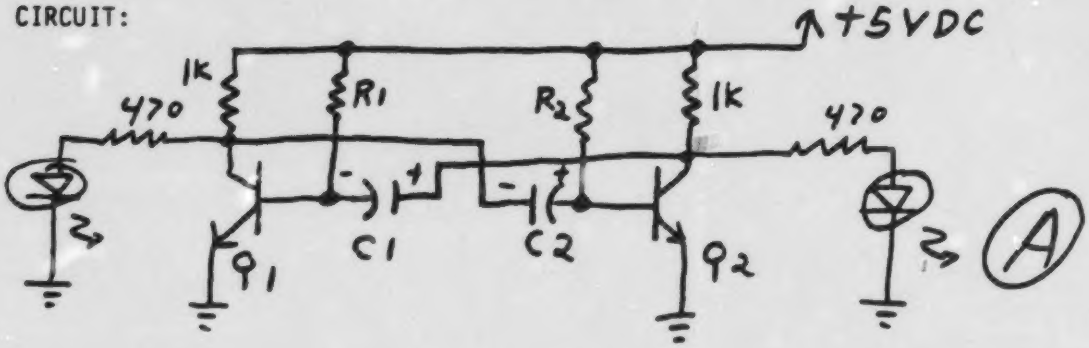
____________________

OBJECTIVE: To observe the operation of a astable multivibrator and IC clock oscillator.

MATERIALS: 2-MPSA-20 (417-801) 2-1K ohm, 2-4.7k ohm, 2-100k ohm, 2-470 ohm, 2-1000uf, 2-33uf, 3-.01uf, SN7404

EQUIPMENT: Power supply, Proto-board, Oscilloscope

CIRCUIT:



PROCEDURE: Construct circuit "A" using for C1 and C2 the 1000uf electrolytic capacitor and for R1 and R2 the 4.7k ohm resistors. Observe the condition of the LED's and the time for one complete output cycle.

4 points 1. Describe the manner in which the LED's switch from one state to another.

2 points 2. Using the values of the timing resistors and capacitors calculate the frequency of oscillation. (Use data from the text if necessary)

Timing resistor ____________

Timing capacitor ____________

Frequency ____________

2 points 3. Using a clock or watch determine the time for one complete cycle.

One cycle ____________

Frequency ____________

PROCEDURE: Replace C1 and C2 with a 33uf electrolytic capacitor.

2 points 1. Calculate the grequency of oscillation

Timing resistor ____________

Timing capacitor ____________

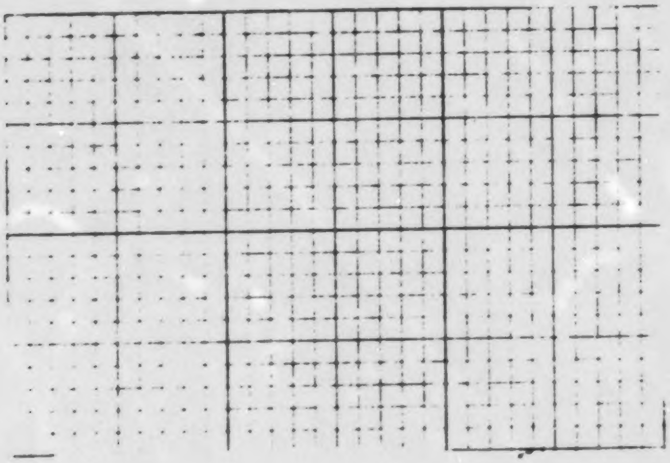
Frequency ____________

2 points 2. Using the oscilloscope measure the frequency of the collector of Q2.

Period ____________ seconds

Frequency ____________

5 points 3. Draw the waveform at the collector of each transistor. Use the dual mode of the scope to observe the phase relationship of the signals.



5 points 4. Using the output waveforms, explain how the circuit operates.

PROCEDURE: Replace C1 and C2 with .01uf ceramic capacitors and R1 and R2 with 100k ohm resistors.

2 points 1. Timing resistor ____________

Timing capacitor ____________

Frequency ____________

3 points 2. Using the oscilloscope measure the frequency at the collector of either transistor.

Period ____________

Frequency ____________

Duty cycle ____________

5 points 3. Draw the waveform at the collector of each transistor remembering their phase relationships.

PROCEDURE: Place an additional .01uf capacitor in parallel with C2.

3 points 1. Using the oscilloscope measure the frequency at Q2.

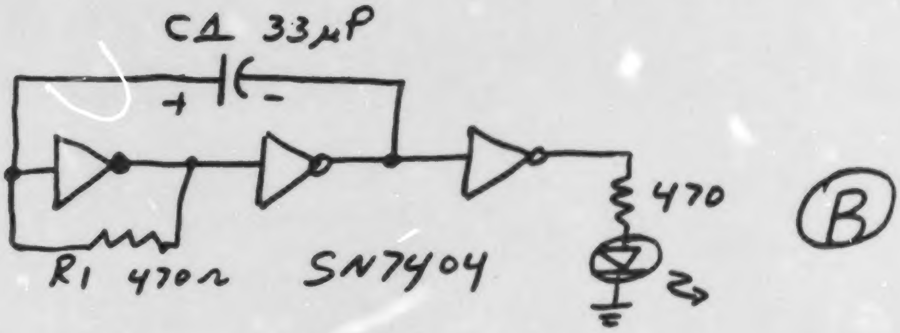
Period ____________

Frequency ____________

Duty cycle ____________

5 points 2. Draw the waveform at the collector of each transistor.

CIRCUIT:



PROCEDURE: Construct circuit "B" and calculate the requested data.

2 points 1. Calculate the frequency using the values of C1 and R1.

Timing resistor ____________

Timing capacitor ____________

Frequency ____________

3 points 2. Using the scope measure the output frequency.

Period ____________

Frequency ____________

Duty cycle ____________

PROCEDURE: Replace C1 with a .01uf capacitor and R1 with a 4.7k ohm resistor.

2 points 1. Calculate the frequency using the values of C1 and R1

Timing resistor ____________

Timing capacitor ____________

Frequency ____________

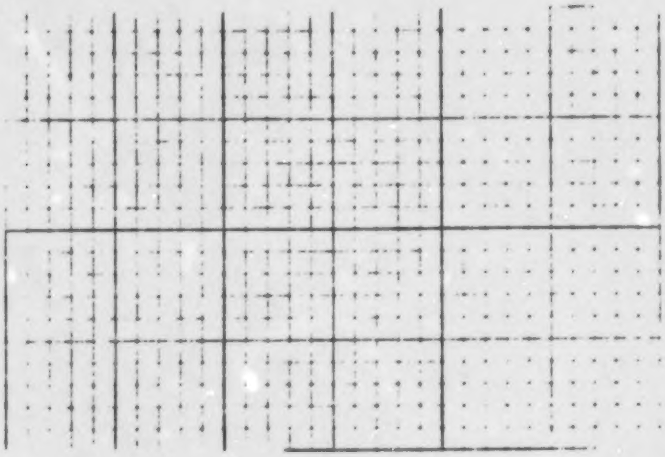
3 points 2. Using the scope at the circuit output, measure the following.

Period ____________

Frequency ____________

Duty cycle ____________

5 points 3. Draw the waveforms at the output of the last gate and at the input of the first gate.



5 points 4. Using the waveforms in step #3 above, explain what each waveform represents.

5 points 5. Using the same waveforms explain how the entire circuit operates.

ET 115
Digital
ONE-SHOT MULTIVIBRATOR

LAB #18
41 points

Name(s) ____________________

____________________

OBJECTIVE: To observe the operation of a retriggerable one-shot multivibrator

MATERIALS: SN74123, IN4149 diode (56-56), 33uf, .1uf, 47k ohm, 4.7k ohm, 2-1k ohm, LED, 470 ohm

EQUIPMENT: Power supply, proto-board, oscilloscope, function generator

DATA:

# CIRCUIT TYPES SN54122, SN54123, SN74122, SN74123
# RETRIGGERABLE MONOSTABLE MULTIVIBRATORS WITH CLEAR

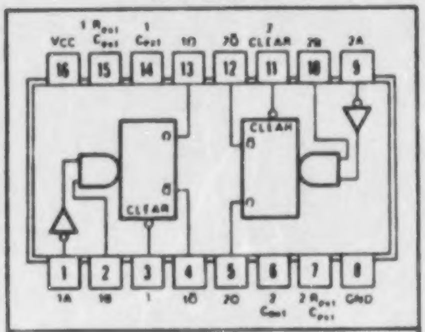
---

- Retriggerable for Very Long Output Pulses, Up to 100% Duty Cycle
- Overriding Clear Terminates Output Pulse
- Diode-Clamped Inputs
- D-C Triggered from High- or Low-Level Gated Logic Inputs
- Compatible for Use with TTL or DTL
- Typical Average Propagation Delay to Output Q . . . 21 ns

SN54123, SN74123
TRUTH TABLE
(See Note A)

| INPUTS | | OUTPUTS | |
|---|---|---|---|
| A | B | Q | $\bar{Q}$ |
| H | X | L | H |
| X | L | L | H |
| L | ↑ | ⎍ | ⊔ |
| ↓ | H | ⎍ | ⊔ |

SN54123, SN74123
J OR N DUAL-IN-LINE OR
W FLAT PACKAGE (TOP VIEW)†
(SEE NOTE D)



**positive logic:**

Low input to clear resets Q to low level and inhibits data inputs

†Pin assignments for these circuits are the same for all packages.

NOTES: A. H = high level (steady state), L = low level (steady state), ↑ = transition from low to high level, ↓ = transition from high to low level, ⎍ = one high-level pulse, ⊔ = one low-level pulse, X = irrelevant (any input, including transitions).

B. NC = No internal connection.

C. To use the internal timing resistor of SN54122/SN74122 (10 kΩ nominal), connect $R_{int}$ to $V_{CC}$.

D. An external timing capacitor may be connected between $C_{ext}$ and $R_{ext}/C_{ext}$ (positive).

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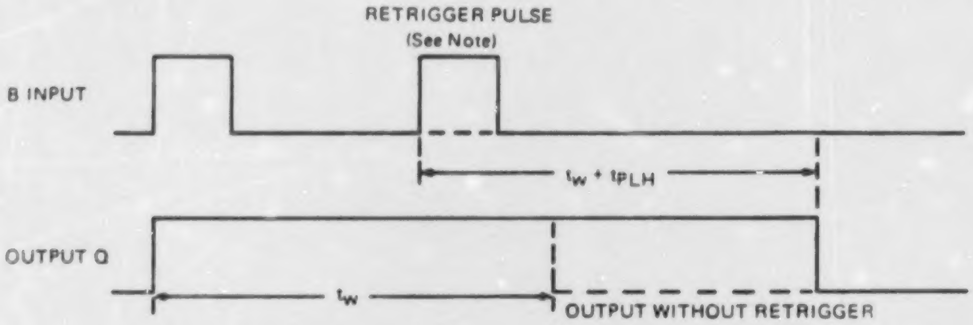
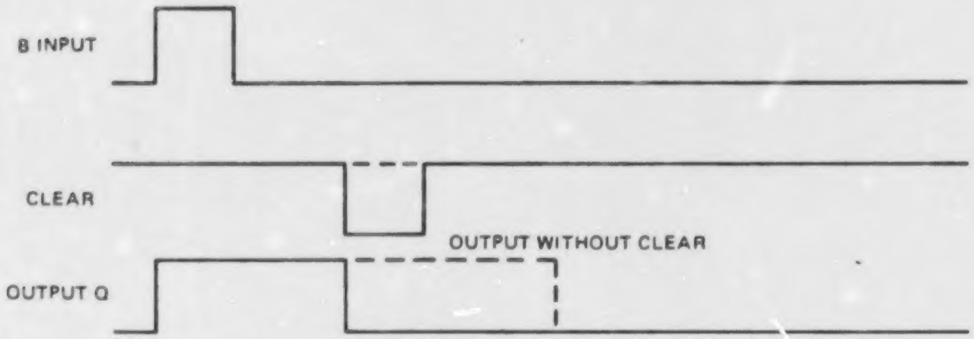
## description

These monolithic TTL retriggerable monostable multivibrators feature d-c triggering from gated low-level-active (A) and high-level-active (B) inputs, and also provide overriding direct clear inputs. Complementary outputs are provided. A full fan-out to 10 normalized Series 54/74 loads is available from each of the outputs at the low logic level, and in the high-level state, a fan-out of 20 is available. The retrigger capability simplifies the generation of output pulses of extremely long duration. By triggering the input before the output pulse is terminated, the output pulse may be extended. The overriding clear capability permits any output pulse to be terminated at a predetermined time independently of the timing components R and C.

Figure A below illustrates triggering the one-shot with the high-level-active (B) inputs.



OUTPUT PULSE CONTROL USING RETRIGGER PULSE



OUTPUT PULSE CONTROL USING CLEAR INPUT

FIGURE A–TYPICAL INPUT/OUTPUT PULSES

NOTE Retrigger pulse must not start before 0.22 $C_{ext}$ (in picofarads) nanoseconds after previous trigger pulse.

These monostables are designed to provide the system designer with complete flexibility in controlling the pulse width, either to lengthen the pulse by retriggering, or to shorten by clearing. SN54122/SN74122 has an internal timing resistor which allows the circuit to be operated with only an external capacitor, if so desired. Applications requiring more precise pulse widths and not requiring the clear feature can best be satisfied with SN54121/SN74121.

The output pulse is primarily a function of the external capacitor and resistor. For $C_{ext} > 1000$ pF, the output pulse width ($t_w$) is defined as:

$$t_w = 0.32\, R_T C_{ext} \left(1 + \frac{0.7}{R_T}\right)$$

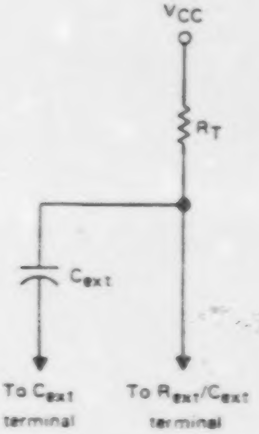
where

$R_T$ is in kΩ (either internal or external timing resistor)
$C_{ext}$ is in pF
$t_w$ is in ns

For pulse widths when $C_{ext} \leq 1000$ pF, see Figure 3.

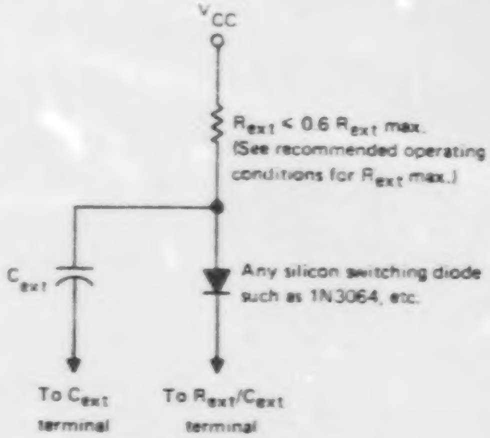
These circuits are fully compatible with most TTL or DTL families. Inputs are diode-clamped to minimize reflections due to transmission-line effects, which simplifies design. Typical power dissipation per one shot is 115 milliwatts; typical average propagation delay time to the Q output is 21 nanoseconds.

## TYPICAL APPLICATION DATA


$V_{CC}$
$R_T$
$C_{ext}$
To $C_{ext}$ terminal
To $R_{ext}/C_{ext}$ terminal

TIMING COMPONENT CONNECTIONS WHEN $C_{ext} < 1000$ pF

FIGURE C


$V_{CC}$
$R_{ext} < 0.6\ R_{ext}$ max.
(See recommended operating conditions for $R_{ext}$ max.)
$C_{ext}$
Any silicon switching diode such as 1N3064, etc.
To $C_{ext}$ terminal
To $R_{ext}/C_{ext}$ terminal

TIMING COMPONENT CONNECTIONS WHEN
$C_{ext} > 1000$ pF AND CLEAR IS USED

FIGURE D

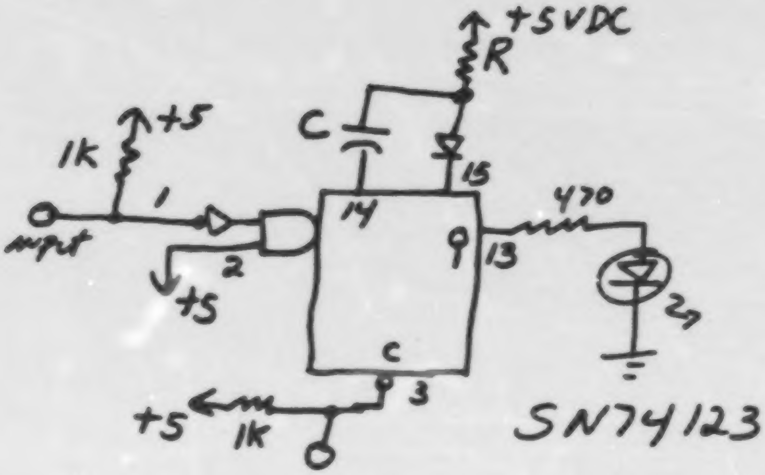
To prevent reverse voltage across $C_{ext}$, it is recommended that the method shown in Figure D be employed when using electrolytic capacitors and in applications utilizing the clear function. In all applications using the diode, the pulse width is:

$$t_w = 0.28\, R_{ext} C_{ext} \left(1 + \frac{0.7}{R_{ext}}\right)$$

where

$R_{ext}$ is in kΩ
$C_{ext}$ is in pF
$t_w$ is in ns

CIRCUIT:



PROCEDURE: Review the data sheet, then construct the multivibrator circuit using a value of 33uf for C and 47K ohms for R. First, calculate (use formula on Page 3) then insert the components into the circuit and time the actual operation. Trigger the circuit by momentarily placing a binary zero on pin number one.

2 points Calculated pulse duration __________

Measured pulse duration __________

PROCEDURE: Experiment with placing a binary zero on input number three.

3 points 1. What is the purpose of input number three?

3 points 2. If a pulse is being timed, what affect will grounding input three have on the output.

PROCEDURE: Replace the 47k ohm resistor with a 4.7k ohm resistor.

2 points Calculated pulse duration __________

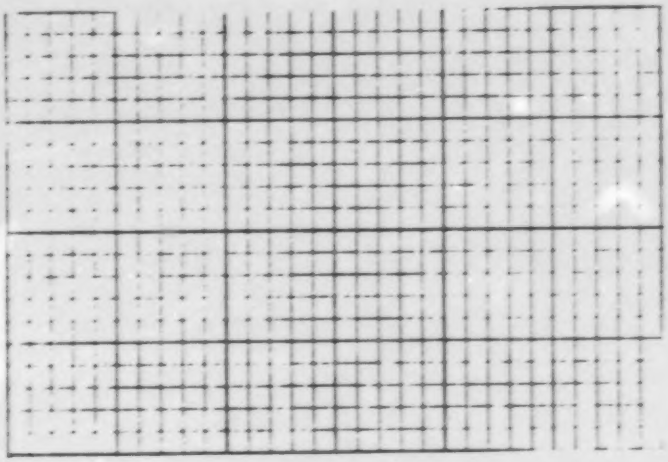
Measured pulse duration __________

PROCEDURE: Replace C and R with a .1uf capacitor and a 47k ohm resistor.

2 points Calculated pulse duration __________

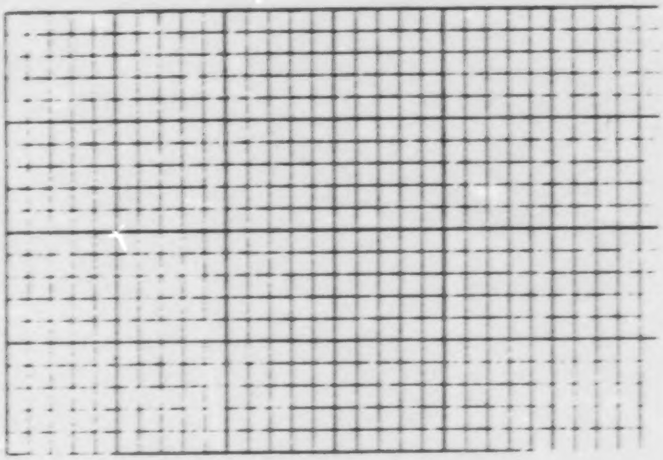
Measured pulse duration __________

PROCEDURE: Connect the TTL output of the function generator to input number one. Attach the scope to the input and output of the SN74123. Vary the frequency (input) to the IC and observe the output of the one shot. Record the waveforms with a 100Hz input signal to the device.



5 points

PROCEDURE: Record the waveforms with a 1KHz input signal.

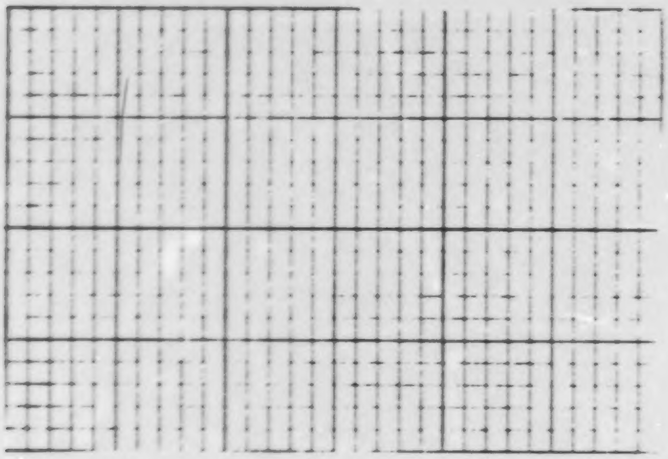


5 points

PROCEDURE: Display both input and output waveforms. Adjust the signal generator to the same frequency as the one shot output, i.e., pulses are the same exact width. Measure this pulse duration.

1 point Pulse duration ___________

PROCEDURE: Place the scope mode switch in the ADD position. Vary the frequency by plus/minus 50Hz and record the waveforms.



5 points

PROCEDURE: Answer the following questions.

3 points 1. Is it possible when using the ADD mode to accurately compare the pulse width of the two signals?

5 points 2. Describe what happens when an input pulse is longer in duration than the one shot time constant.

5 points 3. Describe what happens when the input pulses are shorter in duration than the one shot time constant.

# Appendix C

## Course Evaluations

COURSE NUMBER ET [illegible] SECTION EA SEMESTER Fall YEAR 1984

NAME OF INSTRUCTOR Maint. Elec. Systems J. Jaworski

1. Classification: FR___ Soph___ Jr___ Sr___ Other________

2. What was your reason for enrolling in this course?
   Major___ Required Related___ Elective___ Other________

| INSTRUCTIONS TO STUDENT: CHECK THE COLUMN TO THE RIGHT OF EACH STATEMENT THAT BEST DESCRIBES YOUR EVALUATION OF THIS COURSE AND THE INSTRUCTOR. SPACE FOR COMMENTS IS PROVIDED ON THE BACK | Strongly Agree | Agree | Disagree | Strongly Disagree | Not |
|---|---|---|---|---|---|
| 3. The instructor fully explained course objectives | 2 | 8 | | | |
| 4. The instructor will complete all course objectives | 1 | 7 | 2 | | |
| 5. The course was well organized | | 6 | 1 | 2 | |
| 6. The instructor seemed to be interested in the students' progress in the course | 5 | 5 | | | |
| 7. The instructor clearly explained his or her expectations and grading criteria | 5 | 4 | 1 | | |
| 8. The instructor graded according to the stated expectations and grading criteria | 3 | 6 | | 1 | |
| 9. The instructor seemed well informed in the subject matter | 7 | 3 | | | |
| 10. For assistance outside of class, the instructor was available during office hours | 3 | 7 | | | |
| 11. The textbook(s) required for this course as useful and relevant to the objectives | | | | | 9 |
| 12. Assignments required for this course were relevant to the objectives | 2 | 5 | 1 | 3 | |
| 13. Required reference readings were available in the University library | | 3 | 2 | 2 | 3 |
| 14. The instructor's presentations were clear & helpful | 2 | 6 | 2 | | |
| 15. The instructor was well prepared for each class | 2 | 8 | | | |

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16. Strengths and weaknesses of instructor:

1. I believe the instructor made the class interesting. He went out of his way to explain things. The class was never just a boring lecture. He always encouraged questions and would answer questions after class if someone was still unsure about something. He is always friendly.
2. Knowledge, well informed and very interesting.
3. Interest in subject matter. Weakness seemed to be that he could not refuse to answer questions (even ones irrelevent to his lecture, causing interruption of my train of thought.)
4. Needs to stablize material.
5. He knew electronics well; he lectured too fast to take notes.
6. He has a broad, indepth knowledge of electronics.
7. Instructor knew his material; not enough time to lecture.

17. Strengths and weaknesses of course:

1. I feel less time should have been spent on writing papers and more time spent on preparing and studying technical terms and theories applicable to electronic technology. Papers written about a tour and buying something I know nothing about yet is a waste of time. I much more prefer to study for tests and read appropriate texts.
2. I would have liked to get more into the "how things work" aspect of electronics.
3. The tours were its strong points. Being able to talk to professionals already in the field.
4. The class should have been twice a week instead of once. The tours were interesting; I didn't care for the papers.
5. Not sure of how microprocessor fits into total course.
6. No reference materials to study from other than instructor's handouts.
7. Not enough technical information on electronics.
8. I think it would have been better if we would have met more than once a week.

18. Other comments:

1. I think there should be textbook for this class; there should be some hands-on work.
2. I would like to see the courses offered in the daytime for day students.
3. I was impressed with the instructor and his knowledge of the topics he talked about. I was very disappointed with course because I did not get any of the knowledge out of the course that I expected to get. Somethings that we talked about I felt had nothing to do with the course.

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PS 170. SECTION ________ SEMESTER Spring YEAR 85

INSTRUCTOR Jim Jaworski - Basic Electronics

1. Classification: FR 2 Soph 3 Jr__ Sr__ Other________

2. What was your reason for enrolling in this course?
2 Required Related__ Elective__ Other ________

| INSTRUCTIONS TO STUDENT: CHECK THE COLUMN TO THE RIGHT OF EACH STATEMENT THAT BEST DESCRIBES YOUR EVALUATION OF THIS COURSE AND THE INSTRUCTOR. SPACE FOR COMMENTS IS PROVIDED ON THE BACK | Strongly Agree | Agree | Disagree | Strongly Disagree | Not |
|---|---|---|---|---|---|
| 3. The instructor fully explained course objectives | 3 | 2 | | | |
| 4. The instructor will complete all course objectives | 2 | 2 | 1 | | |
| 5. The course was well organized | | 2 | 3 | | |
| 6. The instructor seemed to be interested in the students' progress in the course | 2 | 2 | 1 | | |
| 7. The instructor clearly explained his or her expectations and grading criteria | 2 | 2 | 1 | | |
| 8. The instructor graded according to the stated expectations and grading criteria | 2 | 2 | 1 | | |
| 9. The instructor seemed well informed in the subject | 4 | 1 | | | |
| 10. For assistance outside of class, the instructor was available during office hours | 1 | 3 | 1 | | |
| 11. The textbook(s) required for this course as useful and relevant to the objectives | 3 | 2. | | | |
| 12. Assignments required for this course were relevant to the objectives | 3 | 2 | | | |
| 13. Required reference readings were available in the University library | | 1 | | | 3 |
| 14. The instructor's presentations were clear & helpful | | 4 | 1 | | |
| 15. The instructor was well prepared for each class | | 4 | 1 | | |

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16. What do you consider to be the main strengths and weaknesses of this instructor? Please explain.

    1. He is very helpful and seems to want the students to learn. He knows the subject matter well.
    2. He seems to be pretty sharp in electronics and willing to help and answer questions. He has a tendency to jump way over your head when answering some questions.
    3. He seemed to know the subject very well and presented it in a way that was easy to understand and pertained to the real life world and not just what a textbook says.
    4. He knows his stuff. He needs to lecture more before assigning new material. I think he should highlight the parts of the book he thinks are important.

17. What do you consider to be the main strengths and weaknesses of this course? Please explain.

    1. It offered the basic electronic information that I needed to continue in electronics.
    2. Textbook is excellent; could use more lab.
    3. The labs were interesting. I wish we could have begun lab work earlier in the course.

18. Other comments.

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COURSE NUMBER ET 110 SECTION EA SEMESTER Spring YEAR 85

NAME OF INSTRUCTOR Jim Jaworski - Solid State Electronics

1. Classification: FR 2 Soph 2 Jr 1 Sr __ Other ____

2. What was your reason for enrolling in this course?
Major 5 Required Related __ Elective __ Other ____

| INSTRUCTIONS TO STUDENT: CHECK THE COLUMN TO THE RIGHT OF EACH STATEMENT THAT BEST DESCRIBES YOUR EVALUATION OF THIS COURSE AND THE INSTRUCTOR. SPACE FOR COMMENTS IS PROVIDED ON THE BACK | Strongly Agree | Agree | Disagree | Strongly Disagree | |
|---|---|---|---|---|---|
| 3. The instructor fully explained course objectives | 2 | 3 | | | |
| 4. The instructor will complete all course objectives | 1 | 4 | | | |
| 5. The course was well organized | | 4 | 1 | | |
| 6. The instructor seemed to be interested in the students' progress in the course | 3 | 2 | | | |
| 7. The instructor clearly explained his or her expectations and grading criteria | 1 | 4 | | | |
| 8. The instructor graded according to the stated expectations and grading criteria | 1 | 4 | | | |
| 9. The instructor seemed well informed in the subject matter | 2 | 3 | | | |
| 10. For assistance outside of class, the instructor was available during office hours | 2 | 3 | | | |
| 11. The textbook(s) required for this course as useful and relevant to the objectives | 1 | 4 | | | |
| 12. Assignments required for this course were relevant to the objectives | 1 | 4 | | | |
| 13. Required reference readings were available in the University library | | 3 | 1 | | 1 |
| 14. The instructor's presentations were clear & helpful | 1 | 2 | 2 | | |
| 15. The instructor was well prepared for each class | 3 | 2 | | | |

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16. What do you consider to be the main strengths and weaknessos of this instructor? Please explain.

Need to explain things better. Start from the basics so everyone can understand.

Strengths - very knowledgeable of the course subject matter and added alot of practical information & applications. Weaknesses - Only one of him and a lot to teach in a short time. I think if we had stayed strictly to the book we would have gotten a good general education, but would have missed a lot of applicable knowledge.

Lectures could have been more organized.

Knowledge of subject matter and practical experience.

17. What do you consider to be the main strengths and weaknesses of this course? Please explain.

Need more hands on training.

My only complaint is S's & HA's. I feel too much time was wasted in class on them. I feel that lecture as opposed to group discussion would be more beneficial. S's & HA's are OK to do at home & hand in as soon as class starts.

Strength - very interesting subject matter to me. Alot of ground to cover in short time.

18. Other comments.

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COURSE NUMBER ET 115 SECTION EA SEMESTER Spring YEAR 85

NAME OF INSTRUCTOR Jim Jaworski - Dig. Elect. Circuit I

1. Classification: FR 3 Soph 2 Jr __ Sr 1 Other ____

2. What was your reason for enrolling in this course?
   Major 6 Required Related __ Elective __ Other ____

| INSTRUCTIONS TO STUDENT: CHECK THE COLUMN TO THE RIGHT OF EACH STATEMENT THAT BEST DESCRIBES YOUR EVALUATION OF THIS COURSE AND THE INSTRUCTOR. SPACE FOR COMMENTS IS PROVIDED ON THE BACK | Strongly Agree | Agree | Disagree | Strongly Disagree | |
|---|---|---|---|---|---|
| 3. The instructor fully explained course objectives | 3 | 3 | | | |
| 4. The instructor will complete all course objectives | | 4 | 2 | | |
| 5. The course was well organized | | 5 | 1 | | |
| 6. The instructor seemed to be interested in the students' progress in the course | 1 | 5 | | | |
| 7. The instructor clearly explained his or her expectations and grading criteria | 2 | 4 | | | |
| 8. The instructor graded according to the stated expectations and grading criteria | 2 | 4 | | | |
| 9. The instructor seemed well informed in the subject matter | 3 | 3 | | | |
| 10. For assistance outside of class, the instructor was available during office hours | 1 | 4 | | | 1 |
| 11. The textbook(s) required for this course as useful and relevant to the objectives | 2 | 2 | 2 | | |
| 12. Assignments required for this course were relevant to the objectives | 2 | 4 | | | |
| 13. Required reference readings were available in the University library | | 4 | | | 2 |
| 14. The instructor's presentations were clear & helpful | | 4 | 2 | | |
| 15. The instructor was well prepared for each class | 1 | 4 | 1 | | |

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16. What do you consider to be the main strengths and weaknesses of this instructor? Please explain.

More lecture time.

Strengths - he is very knowledgeable and friendly. Weaknesses - He should have more quizes and tests to determine students progress.

The instructor should start from a standpoint that everyone doesn't work in the field. He should start the class that people know nothing on the subject. Should spend more time talking about the subject and explaining it. The instructor knows alot about electronics.

Didn't have enough time and/or help to prepare material for labs and class presentations.

17. What do you consider to be the main strengths and weaknesses of this course? Please explain.

The course was a good course.

Book didn't explain some parts very well.

Too much material covered.

18. Other comments.

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# Appendix D

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Dr. William S. Dunlap
Assistant Dean
School of Applied and Continuing Ed.
WASHBURN UNIVERSITY OF TOPEKA
TOPEKA, KS 66621

February 9, 1985

Dear Dr. Dunlap:

After visiting your campus and reviewing the materials that you mailed prior to the visit I would like to make the following observations and recommendations.

My morning visit with Professor Jim Jaworski included a review of the materials that have been developed as well as a visit to the laboratory and a discussion of the text materials currently being utilized.
The instructional materials developed to date are on track as far as the curriculum is concerned however, I believe that the next development period should place an emphasis on written instructional support items as well as more detailed laboratory experiments. The present materials are heavy on tests and quizzes. While testing is important and it will function as both a tool for evaluation as well as instruction it is only a support to experience in the classroom and laboratory.
Most of the text materials I looked at were appropriate but a few were a bit abstract for this level of instruction. Professor Jaworski and I discussed the specifics and I believe he is on the right track and he will continue the review of materials. I would recommend that the text BASIC ELECTRONICS by Bernard Grob 5th Edition from McGraw-Hill be evaluated.
Our discussion of the function of the course The Maintenance of Electronic Systems ET 101 brought to light the fact that Professor Jaworski feels that it is primarily a recruiting course and may at some point in time outlive its usefulness. If in fact the course is only functioning as a recruiting tool and the enrollment is already up to 35 majors in one year I would concur that it might be well to use the credit hours for another purpose. One possibility would be to split BASIC ELECTRONICS PS 170 into a lecture course comprised of circuit analysis and a laboratory course aimed at circuit types (Power Supplies, Amplifiers, Oscillators, etc.) along with fundamentals of instrument usage. This would give the instructor the opportunity to organize the material in a way to give the students the circuit concepts ahead of the actual work on the hardware. The present course does both without much time for the student to assimilate the concept before using it.

Based on my visit to the laboratory facilities I would recommend that the Electronic Maintenance Technology labs be separated from the Science labs because they seem to be lost in the maze of Science equipment. If space is available I believe the separation would be advantageous because the maintenance of solid state and microcomputer

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[illegible] equipment is normally done in a very orderly and clean environment because of the size and complexity of the equipment. Most employers demand good work habits of employees that are hired to maintain this type of equipment. These work habits are learned in the educational environment which should emulate the actual work space found in industry.

The comments that I have made above are not intended to be critical of the individuals in the program as I believe that they have made excellent progress in one short year. My comments and recommendations are intended to improve the program in the hope that it will continue to grow at the present rate and beyond.

Sincerely,

A.O. Brown III
Professor in Charge, Electronics
Pittsburg State University

A.O.Brown III
Professor in Charge of Electronics
Pittsburg State University

[illegible] Box 231A
Pittsburg, KS 66762

# Appendix E

# ARTICULATION AGREEMENT

(Sample)

between

KAW AREA VOCATIONAL TECHNICAL SCHOOL

and

ELECTRONIC MAINTENANCE TECHNOLOGY
SCHOOL OF APPLIED & CONTINUING EDUCATION
WASHBURN UNIVERSITY

## ARTICLE I: DEFINITION

"Articulation is systematic coordination between an educational institution and other educational institutions and agencies designed to insure the efficient and effective movement of students among those institutions and agencies while guaranteeing the students' continuous learning advancement." (Richard J. Ernst, "Articulation: A Working Definition", Community College Review, Spring, 1978). It is "a process of continued specific communication between institutions and common programs, with the student as the primary beneficiary, whereby the economic and timely transfer of the student between institutions is accomplished" in such a manner as "to provide the articulating student with appropriate, non-duplicative learning at the upper level institution to satisfy degree requirements," and to do so "within such a time frame as not to disrupt the continuity of education and career progression." (MICHRIE Articulation Task Force, October, 1983.)

## ARTICLE II: PURPOSE

The purpose of this agreement is to provide a mechanism which will enable graduates from Kaw Area Vocational Technical School, Electronic Technology program to articulate into Washburn University's School of Applied and Continuing Education, Electronic Maintenance Technology degree program with advanced academic standing as provided for in Article IV of this agreement.

## ARTICLE III: PARTICIPATION

Kaw Area Vocational Technical School, Electronic Technology program and Washburn University's School of Applied and Continuing Education, Electronic Maintenance Technology degree program enter into this agreement as equal partners and agree to participate in and administer the agreement in a manner that will maintain the integrity and foster the further growth and development of articulation.

## ARTICLE IV: REQUIREMENTS

### Section I: Criteria for Graduation

Kaw Area Vocational Technical School and Washburn University's School of Applied and Continuing Education, agree that any person who has earned the Certification of Completion in Electronic Technology from Kaw Area Vocational Technical School, and receives a letter of recommendation from the School's director, may transfer to Electronic Maintenance Technology at Washburn and receive a waiver for ET101, advanced placement credit in ET110 and ET115 by matriculation examination, and will be eligible for challenge examinations in ET210, ET220, ET222, ET225, ET240, and PS170 (see Attachment A).

Washburn University strongly recommends the student also complete two years of algebra and one year of physics as part of their school district's graduation requirements.

Section II: Degree Requirements

This transfer eligible person will graduate with an Associate of Applied Science in Electronic Maintenance Technology from Washburn University by completing the following requirements from Washburn University.

1. Complete a minimum of 62 credits.
2. Earn a minimum of 12 credits in the School of Applied and Continuing Education, Washburn University.
3. Earn a minimum of 24 credits at Washburn University.
3. Earn a minimum of 12 of the last 24 hours of the degree program at Washburn University.
5. Earn a minimum of 42 graded credits.
6. Meet Washburn University general education and university graduation requirements
7. Earn a minimum grade of "C" in all major and required related courses.
8. Achieve a minimum overall grade point average of 2.0.

Section III: Washburn University's School of Applied and Continuing Education, Electronic Maintenance Technology Responsibilities

Electronic Maintenance Technology program further agrees:

1. To develop a plan of study consistent with articulating the student's career goals that provides for satisfaction of the degree requirements, (see Attachment B).
2. To provide and/or otherwise advise the student of opportunities for demonstrating proficiency in areas in which he or she may already be competent for advanced standing in the above specified courses.

## ARTICLE V: COMMUNICATION

Kaw Area Vocational Technical School, Electronic Technology program and Washburn University's School of Applied and Continuing Education, Electronic Maintenance Technology degree program agree to cooperate in communicating with each other and with common and respective publics concerning the agreement between their respective programs. Communication will include the development of various kinds of publications to inform people who might benefit personally from the opportunities provided by an associate of applied science degree program at Washburn University based on Certificate of Completion in Electronics Maintenance at Kaw Area Vocational Technical School and should include mention of the articulation agreement in the catalogs of the respective institutions.

## ARTICLE VI: REVIEW

Section I: Responsibility
Kaw Area Vocational Technical School, Electronic Technology and Washburn University's School of Applied and Continuing Education, Electronic Maintenance Technology degree program agree to communicate concerning changes which affect the agreement. Responsibility for communication related to this agreement will be given to the lead electronic technology instructor at Kaw Area Vocational Technical School and the Program Director of Electronic Maintenance Technology at Washburn University's School of Applied and Continuing Education.

Section II: Process
The agreement will be reviewed annually by August 1 for the following academic year for the purpose of assessment, revision and appendage. If there is not significant change, the agreement will be considered as being automatically renewed until such time as either or both parties shall decide to revise, append or terminate the agreement.

## ARTICLE VII: TERMINATION

The agreement may be terminated by either program with the approval of its respective institution.

1. Notification to terminate the agreement must be in writing and submitted no later than the annual review.

2. The agreement shall be honored the two full academic years immediately following the notification to terminate so that those under the agreement at the time of termination may finish their plan of study.

| | |
|---|---|
| Signed: | Signed: |
| Superintendent Date<br>USD #501 | President Date<br>Washburn University |
| Director Date<br>Kaw Area Vocational Technical School | Dean Date<br>School of Applied and Continuing Education |

[illegible] ______________ DATE: ______________

[illegible] ______________ Advisor: ______________

[illegible] ______________

Attachment B

GENERAL EDUCATION & UNIVERSITY REQUIREMENTS:

| Social Science (6 hrs) | Planned | Taken | Grade |
|---|---|---|---|
| | | | |
| | | | |
| Natural Science (6 hrs) | | | |
| | | | |
| | | | |
| Humanities (6 hrs) | | | |
| | | | |
| | | | |
| [illegible] | | | |
| [illegible] | | | |
| | | | |
| | | | |
| REQUIRED MAJOR COURSES: | | | |
| ET 101-2 - The Maintenance of Electronic Systems | | | |
| ET 110-3 - Solid State Electronics | | | |
| ET 115-3 - Digital Electronic Circuit Fundamentals I | | | |
| ET 210-3 - Digital Electronic Circuit Fundamentals II | | | |
| ET 220-3 - Electronic Controls & Industrial Applications | | | |
| ET 222-4 - Intro to Microcomputers | | | |
| ET 235-4 - Advanced Microcomputers | | | |
| ET 240-3 - Technical Troubleshooting Techniques | | | |
| ET 250-3 - Directed Field Experience | | | |
| | | | |
| | | | |
| REQUIRED RELATED COURSES: | | | |
| MA 116-3 - College Algebra | | | |
| PS 151-5 - Intermediate Physics | | | |
| EN 208-3 - Business & Tech. Writing | | | |
| CM 110-3 - Intro to Elect. Data Proc. | | | |
| PS 170-4 - Basic Electronics | | | |
| MA 117-2 - Trigonometry | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Total Credits to Date: ______

__12 of last 24 at Washburn University

__12 at School of Applied & Continuing Education

__24 at Washburn University

__62 hours (Graded)

__ Cumulative G.P.A. ____

Approved by:

Advisor ______________

Dean's Office ______________

Date ______________

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## ATTACHMENT C

## DEFINITIONS

### ARTICULATION

A. "Is a systematic coordination between an educational institution and other educational institutions and agencies designed to insure the efficient and effective movement of students among those institutions and agencies while guaranteeing the students' continuous learning advancement." (Richard J. Ernst, "Articulation: A Working Definition", Community College Review, Spring, 1978).

B. "A process of continued specific communication between institutions and common programs, with the student as the primary beneficiary, whereby the economic and timely transfer of the student between institutions is accomplished" in such a manner as "to provide the articulating student with appropriate, non-duplicative learning at the upper level institution to satisfy degree requirements," and to do so "within such a time frame as not to disrupt the continuity of education and career progression." (MICHRIE Articulation Task Force, October, 1983.)

### CHALLENGE EXAMINATION

Written and/or oral and practical examination of terminal course objectives of specific courses available to Kaw Area Vocational Technical School Certificate of Completion graduates through credit by examination process.

### CREDIT BY EXAMINATION

Credit granted through successful completion of an examination in recognition for knowledge equivalent to that gained through a college level course. The cost is $10.00 per credit hour for the examination, payable prior to taking the examination.

### MATRICULATION EXAMINATION

Available through Washburn's Credit by Examination Process, an oral interview examination by Washburn's Electronic Maintenance Technology Program Director of Kaw Area Vocational Technical School Certificate of Completion graduates. (Interview questions open to Director of Kaw Area Vocational Technical School electronic program.)

### WAIVER OF REQUIRED COURSE

The granting of exemption from ET101 to Kaw Area Vocational Technical School Certificate of Completion graduates. Students must still meet degree requirements of completing 62 credit hours.

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Appendix F

## Articulation Handbook

see CE 042 237